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West Point, New York 10996

Lead-the-Fleet: Transitioning Army Aviation Maintenance From a Time Based System to a Usage Based System

OPERATIONS RESEARCH CENTER OF EXCELLENCE
TECHNICAL REPORT DSE-TR-0406
DTIC #: ADA426343

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The Operations Research Center of Excellence is supported by the Assistant secretary of the Army (Financial Management & Comptroller)

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Abstract

Army helicopter system and component scheduled maintenance, overhaul, and retirement actions typically are based on calendar times and flight hours. These times are based on a composite worst-case (CWC) presumption of helicopter regime usage. CWC usage is derived by manufactures for each U.S. Army helicopter model to capture the most severe usage that helicopter models can ever be expected to experience. The purpose of the Lead the Fleet (LTF) program is to gain better insight into the accumulated damage that each U.S. Army helicopter could experience during actual operational usage. That knowledge can then be used to more closely identify overhaul and retirement times, increase safety and operational readiness, reduce costs, and recommend condition based maintenance actions. The US Military Academy's Operational Research Center of Excellence (ORCEN) was asked in by the Lead-the-Fleet program officer to analyze the program and make recommendations. This technical report details our findings on this research.

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Table of Contents

List of Figures

Chapter 1 Introduction

1.1 Time Based Helicopter Maintenance

U.S. Army helicopters are extremely complex machines designed to perform within broad operational usage envelopes. The operational usage envelopes are defined by discrete flight regimes that consist of combinations of aircraft configurations and flight maneuvers. Each regime can occur in combination with varying values of engine torque and speed, aircraft velocity, rotor speed, and other factors. Army helicopter systems and component scheduled maintenance, overhaul, and retirement actions typically are based on calendar times and flight hours. These times are based on a composite worst-case (CWC) presumption of helicopter regime usage. CWC usage is derived for each U.S. Army helicopter model to capture the most severe usage that each helicopter can ever be expected to experience.

Knowledge of actual operational usage can be used to identify unsafe usage, refine scheduled maintenance actions, and predict unscheduled maintenance requirements. One of the purposes of the Lead the Fleet (LTF) program is to gain better insight into the accumulated damage that each U.S. Army helicopter could experience during actual operational usage and to use that knowledge to evaluate overhaul and retirement times, increase safety and operational readiness, and reduce costs.

1.2 Lead The Fleet (LTF) Approach to Helicopter Sustainment

The LTF approach is to increase the flight-hour rate and usage intensity of selected Army helicopters to identify safety, reliability, availability, maintainability, and logistics issues before they occur during normal operational usage. In this manner, system and component deficiencies can be identified, addressed, and corrected prior to fleet-wide requirements for costly restorations, modifications, or retrofits. LTF provides the early opportunity to capture aircraft usage information that can be correlated with discrepancies and failures to establish meaningful usage-related safety and logistical trends. As a minimum, LTF will monitor and record the amount of time each airframe and each dynamic component is exposed to damaging flight regimes and evaluate the resultant accumulated damage. The basic parameters required to

identify these flight regimes include gross weight, airspeed, altitude, roll angle, vertical acceleration, and ground-air-ground cycles.

The LTF mission objectives include [1,2]: 1) Safely conduct controlled flight in extreme environments at the highest sustained OPTEMPO in the Army to accelerate the total accumulated damage of Fatigue Life Limited (FLL) Critical Safety Items (CSIs) and compare damage intensities to specific flight regimes within the mission profiles. 2) Perform maintenance in a well-structured environment focusing on technical manual accuracy, repair parts quality, tools, and maintenance man-hours expended. 3) Capture detailed maintenance and usage data suitable to conduct required engineering analysis and conclusions. Conduct in-depth engineering maintenance and usage data analysis and reporting and 4) Develop methodologies and procedures suitable to conduct fleet-wide maintenance and usage data analysis.

1.3 LTF History and Background

The genesis for the present LTF Program dates from an earlier LTF program that ran from 1986 through 1995. This earlier LTF program resulted in 11 Modification Work Orders (MWOs), 13 Engineering Change Proposals (ECPs) and 11 other changes to aviation maintenance practices and procedures that generated approximately 100 million dollars in operations and support (O&S) costs savings to the Army. Present day information technology was nonexistent and thus data collection was primarily gathered through data collection cards resulting in analyses through stubby-pencil work. The program, while largely successful, was terminated in 1995 because of funding constraints.

In July 2001, the Vice Chief of Staff, Army (VCSA), acting on a recommendation from the Aviation Task Force, re-instituted the LTF program. Initial funding was provided on 1 April 2002 with the first flight commencing on 31 May 2002. The emerging results demonstrate the program's potential to enhance readiness, reduce operating and support costs and improve aviation safety. Recent program reviews have highlighted growing interest in using LTF Program processes and results to aid in fleet management and airworthiness assurance within the Aviation and Missile Command (AMCOM) and Program Executive Office – Aviation (PEO-Aviation). [1]

1.4 LTF and Operations Research Partnership

The Operations Research Center of Excellence (ORCEN), at the U.S. Military Academy, West Point, NY works with Lead-the-Fleet as an independent analysis section to advise LTF of system engineering program development issues, statistical analysis, and cost savings validation. The ORCEN advises LTF on design of experiments to gain better insights into the accumulated damage that each U.S. Army helicopter could experience during actual operational usage. With the ORCENs assistance the LTF program will recommend changes to Army Aviation overhaul and retirement times, increase aviation safety and operational readiness, and reduce costs, ultimately helping to successfully transform the Army's aircraft maintenance program from a flight time based to a usage based system. During initial problem definition, ORCEN analysts conducted a through review of existing documentation and interviews of appropriate personnel to fully understand the current LTF mission. The first step taken in problem definition was identifying key players, agencies and major support functions.

1.5 Lead-The-Fleet (LTF) Key Agencies

The large scale LTF program consists of many agencies and players. The following is a list of key agencies which all must pass information and communicate effectively in order for the LTF program to succeed.

1.5.1 Aviation and Missile Research, Development, and Engineering Center (AMRDEC) Test and Evaluation Management Office (TEMO)

Aviation and Missile Research, Development, and Engineering Center (AMRDEC) Test and Evaluation Management Office (TEMO) is responsible for managing the U.S. Army Aviation LTF Program. The purpose of LTF is to rapidly accumulate flight hours on individual Force Mod Aircraft to identify safety; reliability, availability, and maintainability (RAM); and logistical issues before they occur during operational usage in the field. AMRDEC is the leading sponsor of the LTF program.

1.5.2 Army Aviation Technical Test Center (ATTC)

ATTC is the executors of the program. Developmental test pilots fly relatively severe mission profiles and rapidly accumulate flight hours to ensure operational usage-related discrepancies and failures occur during the LTF program instead of occurring in the field. The ATTC AMPOL data acquisition system will monitor operational events of LTF aircraft equipped with MIL-STD-1553 data buses, and flight crews will log operational flight events of non-bused aircraft. Operational and maintenance events will be entered into a RAM data collection and management database.

1.5.3 The Aviation Engineering Directorate (AED)

The Aviation Engineering Directorate (AED) has the responsibility to coordinate with ATTC to identify and evaluate potential LTF aircraft discrepancies and failures. AED will analyze the UniRAM database to establish safety and logistical trends that result from the rate and severity of LTF operational usage. AED must work with the PMOs and OEMs to develop engineering changes, solutions, qualification requirements, and maintenance procedures to resolve LTF discrepancies and trends before they adversely impact aircraft in the field.

1.5.4 Westar Corporation

Westar Corporation, under the Omnibus 2000 (O2K) Support Services Contract, currently provides on-site support to Aviation Engineering Directorate (AED) Structures and Materials, Propulsion, Aeromechanics, and Mission Equipment. As a result, Westar is uniquely positioned to interface with ATTC and each of the functional AED divisions to support the successful implementation of LTF objectives. In addition, as an O2K Technical Prime Contractor, Westar has access to its 46 subcontractors who can provide any degree of technical support required to fully realize the benefits of LTF.

1.5.5 COBRO Corporation

COBRO Corporation, a Westar Company, is under a five-year contract to provide Omnibus Test Support Services (OTSS) to ATTC. COBRO will collect, process, analyze, and

archive LTF usage and maintenance data into their UniRAM relational database management system. UniRAM was developed in ORACLE and has been adapted for the operational testing requirements of the LTF program.

1.5.6 Operations Research Center of Excellence (ORCEN)

Operations Research Center of Excellence (ORCEN) provides system engineering analysis, statistical and analytical research to support the current LTF efforts. LTF requested that the ORCEN determine the statistical significance of the current LTF data in relation to the rest of the Army fleet in regards to OPTEMPO, Reliability, Availability and Maintainability (RAM) data. In addition determine the number of aircraft, flight hours and duration required to statistically represent (with 90% Confidence Interval) the entire fleet during Phase 2, and determine the statistical significance of LTF data with 25 aircraft expansion during Phase 2. The ORCEN works in conjunction with LTF to assist LTF with program issues and provides timely feedback of LTF concerns.

Chapter 2 ORCEN and the LTF Program

2.1 ORCEN Problem Definition

The ORCEN sought to provide accurate statistical data analysis for specific LTF questions, including: 1) to statistically represent current LTF data with the rest of the Army, and 2) predict the amount of time Phase 2 would last with in a 90% confidence interval. When looking at requirement number one, it became apparent that LTF data was unique and did not correlate with Army fleet aircraft data. In addition, when attempting to predict the length of time for Phase 2, the first question asked was, "what data does LTF want to validate in Phase 2?" This thinking led the ORCEN to ask fundamental questions of what LTF wanted to accomplish in each phase of the program.

Continued questioning in this vain, coupled with the lack of direct answers, led the ORCEN analyst to conclude that a holistic system engineering analysis for the program was warranted. A systems engineering break down of the LTF program would address the above questions and would fulfill LTF objectives and goals, ultimately, leading to metrics for the ORCEN to analyze.

The ORCEN conducted a top down review of the LTF program to seek answers to these questions in order to find the metrics needed to provide a statistical analysis of the program. During this review we determined that the LTF program objectives were too broad and did not establish any quantified measures of success or expected results. To provide proper direction and a complete system engineering analysis, clear goals, objectives and measures of effectiveness (MOE) needed to be established.

2.2 ORCEN Recommends Program Restructuring

The ORCEN met with the LTF Program Manager (PM) on 26FEB04 to purpose a restructuring of the LTF Program to enable better articulation of the program and enable the ORCEN to gather the metrics necessary to complete a statistical analysis of the program data. The PM agreed and provided the backing and latitude to the ORCEN to go ahead with a systems engineering approach to make a recommendation for a new LTF program plan. To do this, the

ORCEN conducted several meetings with all key players within LTF to redefine the LTF program including: organization of the program into four separate studies each including 1) mission, 2) goals, 3) objectives and 4) measures of effectiveness which support the overall LTF program mission. The ORCEN discussed the new concept with each stakeholder to gain team support and insight into the new LTF program plan. Each stakeholder eagerly provided input and recommendations for the new program plan. The ORCEN tracked and compiled all recommendations and produced a new concept plan for the LTF program. This new plan and thought process was then organized into a LTF program plan which is currently under review for publication by the LTF PM.

This new program plan redefines the LTF program and provides better articulation of the program for both the program executors and the program managers. With the approval of the new LTF program plan, the program will become more organized, understandable, better defined, and enable the tracking of the status of the program through realistic measures of effectiveness. The measures of effectiveness will allow the program to track its status and enable tracking of metrics to help validate the statistical significance of the program.

2.3 ORCEN Analysis of LTF Data Collection

One of the key areas of concentration for the ORCEN was to analyze the data collection process of the LTF program. In this analysis the ORCEN sought to answer the following questions: 1) What data is collected and why? 2) How is the data collected? 3) Is the current data collection process suitable for Phase 2? 4) How accurate is the collected data? 5) Who uses the data? 6) What direct questions does the data answer? 7) What data should LTF collect and why?

2.3.1 LTF Data Collection Process

One of LTFs missions is to capture aircraft usage information and correlate with discrepancies and failures in order to establish meaningful usage related safety and logistical trends. As a minimum, the amount of time each aircraft and each dynamic component spends in damaging flight regimes are monitored and recorded. The basic parameters required to identify the flight regimes include gross weight, airspeed, altitude, roll angle, and vertical acceleration. This data must be collected using a Digital Source Collector (DSC). Some aircraft (AH64A/D,

CH47F) are already equipped with buses to capture this data, however most Army aircraft (UH-60A, UH-60L, CH-47D) do not have this capability and a DSC must be installed on these aircraft. Currently, LTF is using a system called DataMARS for the AH-64A/D and CH-47F. The DataMARS records the buss traffic which captures weapons, engine, temperature, altitude, orientation, and stick position data; and the GPS/INS data which provides state information. The data is then written onto a 2 Gigabyte PCMCIA card. For the non-buss aircraft (UH-60A/L and CH-47) LTF is testing a systems called C-MIGITS which records data from the Global Positioning System (GPS) and Inertial Navigation System (INS). The data streams are combined to provide flight path and state information that is written onto a 64 megabyte PCMCIA card. LTF is testing additional DSC's including Vibration Management Enhancement Program (VMEP); and the Goodrich Aerospace developed Integrated Mechanical Diagnostic System (IMDS), Health and Usage Monitoring System (HUMS), referred to as IMDS HUMS.

The LTF data collection process during Phase 1 is complex and personnel intensive, however efforts are beginning to streamline and automate the data collection process for Phase 2 [1]. The ORCEN has recommended that LTF develop an engineering methodology to associate each part failure with aircraft usage to start building a data baseline for usage based maintenance. Part of this engineering methodology includes the data collection system for each aircraft as well as the data tracking system and analysis of data to make recommendations to go forward to a usage based maintenance system.

Chapter 3 New LTF Business Plan

3.1 ORCEN Results

The results of the ORCEN analysis are summarized in the culmination of the LTF business plan executive summary (Appendix A) and the LTF business plan (Appendix B). The ORCEN facilitated the beginnings of the LTF business plan and developed the LTF program plan which was used as a basis for the final LTF Business plan. The ORCEN facilitated several working group meetings with all members of the LTF team to gain insight and publish the LTF program mission, goals, objectives and measures of effectiveness. The following sections are the results of these meetings.

3.1.1 Mission:

The Lead the Fleet program is a holistic systems engineering approach to solving critical problems associated with Army aviation component reliability, safety, readiness, and operations and support (O&S) cost drivers.

3.1.2 LTF Program Goals

Reduce O&S Cost Drivers

Improve Readiness

Improve Safety through Early Hazard Identification and Risk Mitigation

Improve Resource Requirements Forecasting (Parts, Manpower and Money)

3.1.3 LTF Program Goals, Objectives and Measures of Effectiveness (MOE)

3.1.3.1 LTF Program Goal 1: Reduce O&S Cost Drivers

Objective 1-1: Identify the appropriate data, collection, analysis and dissemination system

MOE 1-1-1: At least twice the Army field OPTEMPO

MOE 1-1-2: Efficient Digital Source Collection (DSC) system

MOE 1-1-3: Number of Technical Summary of Findings (TSOF)

MOE 1-1-4: Number of actionable technical investigations by appropriate agencies.

Objective 1-2: Identifying parts that do not meet engineering specifications

MOE 1-2-1: Number of noncompliant aviation parts identified per quarter

MOE 1-2-2: Cost savings

Objective 1-3: Identifying new or improved maintenance processes and/or procedures

MOE 1-3-1: Number of new maintenance processes

MOE 1-3-2: Number of improved maintenance processes

MOE 1-3-3: Cost savings

Objective 1-4: Reduce Maintenance Man Hours (MMH)

MOE 1-4-1: Number of maintenance man hours (MMH) per quarter per aircraft.

MOE 1-4-2: Cost savings

3.1.3.2 LTF Program Goal 2: Improve Readiness

Objective 2-1: Identify actionable cost and readiness drivers to appropriate Army agencies and track until closure

MOE 2-1-1: At least twice the Army field OPTEMPO

MOE 2-1-2: Efficient Digital Source Collection (DSC) system

MOE 2-1-3: Number of Technical Summary of Findings (TSOF)

MOE 2-1-4: Number of actionable technical investigations by appropriate agencies

Objective 2-2: Reduce Maintenance Man Hours (MMH)

MOE 2-2-1: Percent reduction in MMH

Objective 2-3: Early identification of system failures

MOE 2-3-1: Number of correctable failure modes prior to OEM

MOE 2-3-2: Number of actionable Tactics, Techniques and Procedures (TTP) Maintenance, Technology, DTLOMS

Objective 2-4: Improve and sustain Mission Capability (MC) rates x % per year for y years (MC = FMC + PMC)

MOE 2-4-1: Monthly MC rate. Method: Conduct repair part analysis, and identify processes to fix

MOE 2-4-2: Number of linkages found between reason for failed parts and part demand history

3.1.3.3 LTF Program Goal 3: Improve Safety through Early Hazard Identification and Risk Mitigation

Objective 3-1: Identify the appropriate data, collection, analysis and dissemination system

MOE 3-1-1: At least twice the Army field OPTEMPO

MOE 3-1-2: Efficient Digital Source Collection (DSC) system

MOE 3-1-3: Number of Technical Summary of Findings (TSOF)

MOE 3-1-4: Number of actionable technical investigations by appropriate agencies.

Objective 3-2: Early identification of safety of flight component failures

MOE 3-2-1: Number of correctable failure modes prior to OEM

MOE 3-2-2: Number of actionable Tactics, Techniques and Procedures (TTP), Maintenance, Technology, DTLOMS

MOE 3-2-3: Changes in the number of Safety of Flight (SOF) messages

MOE 3-2-4: Changes in the number of Aviation Safety Action Message (ASAM)

3.1.3.4 LTF Program Goal 4: Improve Resource Requirements Forecasting (Parts, Manpower and Money)

Objective 4-1: Identify actionable cost and readiness drivers to appropriate Army agencies and track until closure

MOE 4-1-1: At least twice the Army field OPTEMPO (Need MTBF)

MOE 4-1-2: Efficient Digital Source Collection (DSC) system

MOE 4-1-3: Number of Technical Summary of Findings (TSOF)

MOE 4-1-4: Number of actionable technical investigations by appropriate agencies

Objective 4-2: Improve the fidelity of our parts forecast (by usage based)

MOE 4-2-1: Number of correct forecasts (Liking part history to part failure)

Objective 4-3: Identify manpower requirements

MOE 4-3-1: Number of changes (Analysis: Linking manpower to repair parts)

Objective 4-4: Improve the fidelity of the budget forecast (by usage based)

MOE 4-4-1: Number of correct forecasts

3.1.4 The LTF Program Objectives (Figure 1):

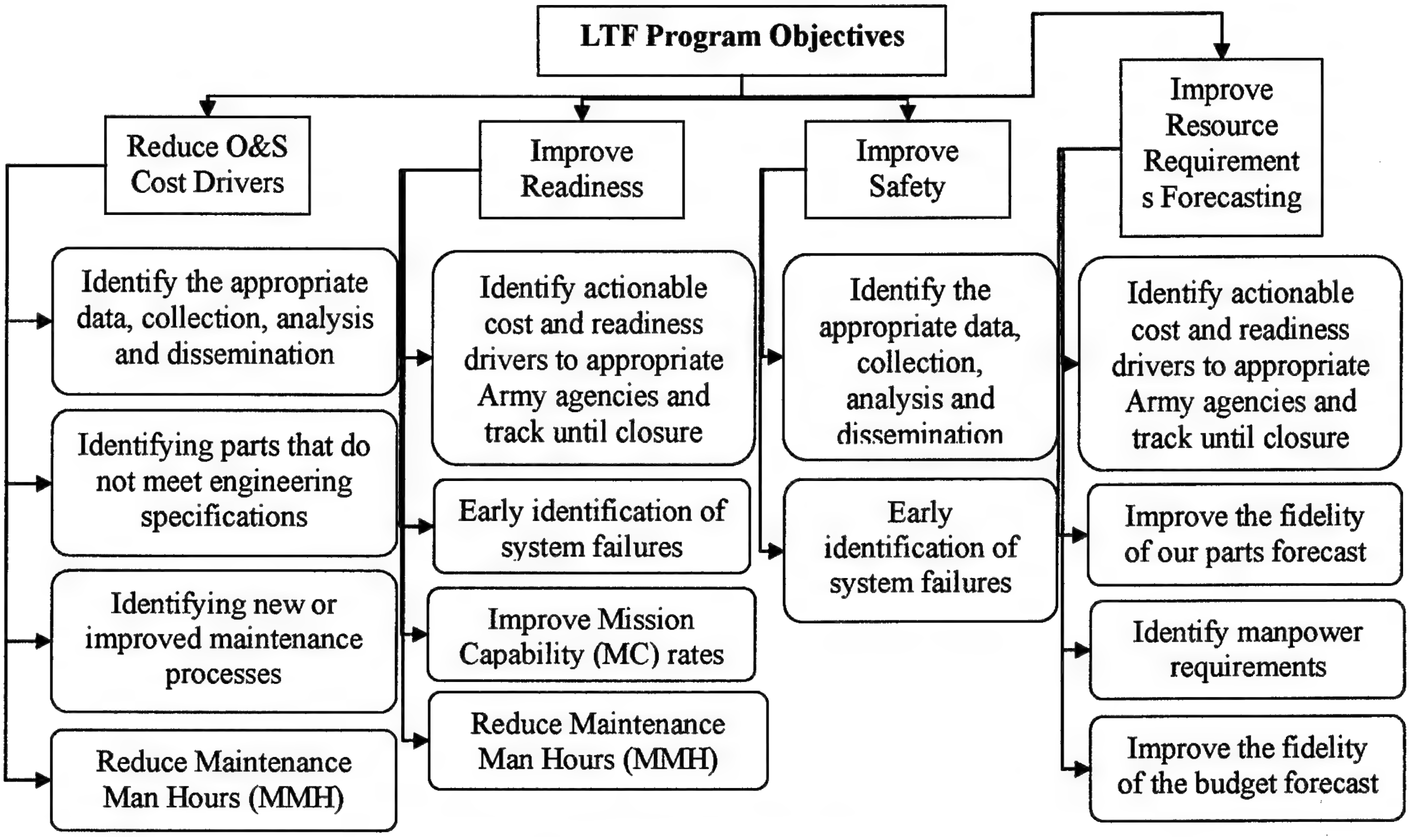

Figure 1: LTF Program Objectives

3.1.5 LTF Program Analysis

To accomplish these goals and objectives the LTF program consists of several subprograms, each one called an "analysis." Each analysis contributes to the LTF goals and objectives in varying ways. Currently the major analysis that support the LTF program include: 1) time to usage, 2) Health Usage Monitoring (generic), 3) Aviation Logistics Life Cycle management analysis and implementation, and 4) Concentric or Synergistic Environment Testing (Figure 2). The mission, goals, objectives, and measures of effectiveness for each of these analysis are shown below:

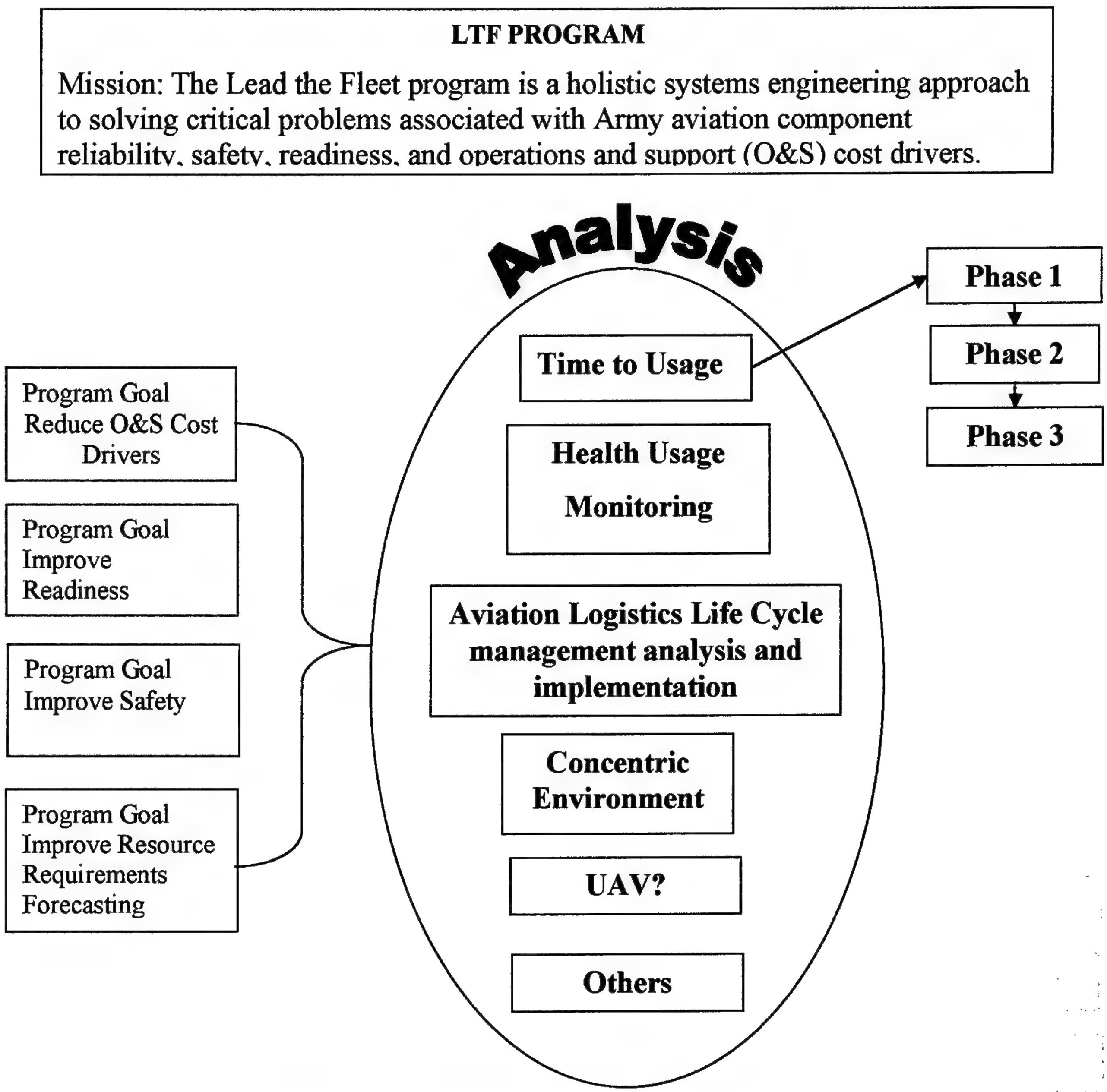

Figure 2: LTF Program Analysis Breakdown

3.1.5.1 LTF Analysis: "Time Based to Usage Based"

The LTF analysis of time based to usage based maintenance equips decision makers with information to change maintenance policy to a usage based maintenance program to support the LTF program. The definition of usage based maintenance changes aircraft parts based on actual aircraft usage not aircraft flight hours. The goals include: 1) Reduce O&S Cost Drivers, 2)

Improve Readiness and 3) Increase Safety. The goals, objectives and measures of effectives for time to usage based maintenance follow:

3.1.5.1.1 LTF Analysis: "Time Based to Usage Based" Goal 1: Reduce O&S Cost Drivers

Objective 1-1: More reliable parts that last "longer" in regime that we want to use it in

MOE 1-1-1: Number of more reliable parts

MOE 1-1-2: % of MC increase

MOE 1-1-3: Increase in Maintenance Time Between Failures (MTBF)

Objective 1-2: Reduce Man Hours (MH)

MOE 1-2-1: Number of Man Hours reduced

Objective 1-3: Increase proper Forecasting (on time supply, with out excess inventory)

MOE 1-3-1: Percent of correct forecasting for failed parts

Objective 1-4: Usage savings, parts only replaced when necessary (Inventory control, less parts needed on hand, Stock, others)

MOE 1-4-1: Amount of money saved.

Objective 1-5: Reduce maintenance test flight hours

MOE 1-5-1: Percent of maintenance test flight hours = (MTFH)/(Total A/C hours) per quarter.

3.1.5.1.2 LTF Analysis: "Time Based to Usage Based" Goal 2: Improve Readiness

Objective 2-1: More reliable parts that last "longer" in regime that we want to use it in.

MOE 2-1-1: Number of more reliable parts

MOE 2-1-2: % of MC increase

MOE 2-1-3: Increase in Maintenance Time Between Failures (MTBF)

Objective 2-2: Increase proper Forecasting (on time supply, with out excess inventory)

MOE 2-2-1: Percent of correct forecasting for failed parts

Objective 2-3: Reduce maintenance test flight hours

MOE 2-3-1: Percent of maintenance test flight hours = (MTFH)/(Total A/C hours) per quarter.

Objective 2-4: Increase Mission Capability (MC) rates to 90% MC

MOE 2-4-1: Percent MC

3.1.5.1.3 LTF Analysis: "Time Based to Usage Based" Goal 3: Safety

Objective 3-1: Replacement of parts before operational failure

MOE 3-1: Number of replaced parts prior to failure

3.1.5.2 Time to Usage Based Phases

The initial funding and tailoring of the LTF program followed three phases. For the time to usage based analysis the following is a list of goals and questions to be answered by the end of each phase:

3.1.5.2.1 Phase 1 Goals

1. ***Develop efficient methodology for implementation of Phase 2.***
   A. *Data collection, storage, transmission, flow.*
   B. *Aircraft instrumentation.*
   C. *Number of people needed for phase 2*
   D. *Structure needed for phase 2*
   E. *Reporting process (automated PQDR and TIR)*
   F. *Tying failure to time history (birth to death tracking of parts)*
2. ***Develop process to determine engineering model for time to usage based maintenance***
3. ***Develop flight profile means using a Digital Source Collection (DSC) capability to accurately determine regime recognition including as a minimum: aircraft flight profile, gross weight, environment, and weather.***
4. ***Ensure transparent phase 2 implementation for user***
   A. *No change to way aircrews fly*
   B. *No change to way crew chiefs maintain (unless more efficient)*
   C. *No change to unit*
5. ***Collect maintenance, regime, and profile data to establish baseline***

3.1.5.2.2 Questions to answer by end of phase 1:

1. *How to efficiently collect Reliability, Availability and Maintainability (RAM) data from field aircraft including QDR, ITR, and reporting process?*
2. *How are the aircraft flown?*
3. *How to correlate the way the aircraft is flown to part damage?*
4. *What quality RAM data do we need to collect and why?*

3.1.5.2.3 Goals of Phase 2

1. ***Validate Phase 1 methodology (Crew Data)***
   A. *Incorporate changes to phase 1 methodology if needed*
2. ***Correlate Phase 1 flight profiles***
3. ***Validate process for engineering model***
4. ***Recommend Go/NoGo to decision makers for phase 3 implementation***

3.1.5.2.4 Questions to answer by end of phase 2:

1. *What improved DSC system capability should go onto aircraft to implement regime recognition?*
2. *When does part fail?*
3. *How is aircraft flown?*
4. *What adjustments are needed in methodology?*
5. *What adjustments are needed to normalize baseline data?*

3.1.5.2.5 Goals of Phase 3

1. ***All fleet aircraft are using usage based maintenance***
2. ***Reduce O&S Cost Drivers***
3. ***Improve Readiness***
4. ***Improve Safety through Early Hazard Identification and Risk Mitigation***
5. ***Improve Resource Requirements Forecasting (Parts, Manpower and Money)***

3.1.5.3 LTF Analysis: Health Usage Monitoring System (HUMS) generic

The Lead the Fleet Analysis on "HUMS" equips decision makers with information to change maintenance policy to a "HUMS" based maintenance program to support the LTF program. The definition of a Health Usage Monitoring System (HUMS) is a system that digitally detects and analysis's failures before they become flight critical. The goals include: 1) Reduce O&S Cost Drivers, 2) Improve Readiness and 3) Increase Safety. The goals, objectives and measures of effectives for time to usage based maintenance follow:

3.1.5.3.1 LTF Analysis: Health Usage Monitoring System (HUMS) generic Goal 1: Reduce O&S Cost Drivers

Objective 1-1: Reduce Man Hours (MH) due to reduced inspections

MOE 1-1-1: Number of Man Hours reduced

Objective 1-2: Increase Forecasting (on time supply, with out excess inventory) by providing lead time.

MOE 1-2-1: Percent of correct forecasting for failed parts

Objective 1-3: Inventory savings (Inventory control, less parts needed on hand, Stock, others)

MOE 1-3-1: Amount of money saved.

Objective 1-4: Reduce maintenance test flight hours (Reduce trouble shooting time)

MOE 1-4-1: Percent of maintenance test flight hours = (MTFH)/(Total A/C hours) per quarter.

3.1.5.3.2 LTF Analysis: Health Usage Monitoring System (HUMS) generic Goal 2: Improve Readiness

Objective 2-1: Increase proper Forecasting (on time supply, with out excess inventory)

MOE 2-1-1: Percent of correct forecasting for failed parts

Objective 2-2: Reduce maintenance test flight hours (Reduce trouble shooting time)

MOE 2-2-1: Percent of maintenance test flight hours = (MTFH)/(Total A/C hours) per quarter.

Objective 2-3: Increase Mission Capability (MC) rates to 90% MC

MOE 2-3-1: Percent MC

3.1.5.3.3 LTF Analysis: Health Usage Monitoring System (HUMS) generic Goal 3: Safety

Objective 3-1: Replacement of parts before operational failure

MOE 3-1-1: Number of parts replaced with in 5% of operational failure.

3.1.5.4 LTF Analysis: Aviation Logistics Life Cycle management analysis and implementation

The Lead the Fleet Analysis on "Aviation Logistics Life Cycle management analysis and implementation" is a focused application, analysis and implementation of logistics techniques and procedures to support LTF program. The goals include: 1) Reduce O&S Cost Drivers, 2) Improve Readiness and 3) Increase Safety. The goals, objectives and measures of effectives for time to usage based maintenance follow:

3.1.5.4.1 LTF Analysis: Aviation Logistics Life Cycle management analysis and implementation Goal 1: Reduce O&S Cost Drivers

Objective 1-1: Identify 1) Proper utilization of parts (Did we use part as it was intended to be used), 2) Non compliant to specification parts, 3) Inadequate critical characteristics (Inadequate specifications), and 4) Inadequately defined requirements.

MOE 1-1-1: Number of actionable bad parts

Objective 1-2: Identify inadequate Techniques and Procedures (Modifications, Special Tools, more efficient procedures, reduce required inspections and test flights)

MOE 1-2-1: Number of actionable techniques and procedures

MOE 1-2-1: Number of Man Hours (MH) reduced per quarter

Objective 1-3: Alert Decision Makers with adequate information to make changes to Techniques and Procedures

MOE 1-3-1: Number of Technical Summary of Findings (TSOF)

MOE 1-3-2: Number of Product Quality Deficient Report (PQDR)

MOE 1-3-3: Number of Test Incident Report (TIR)

MOE 1-3-4: Number of 2028s (Recommendations to change a reference material)

Objective 1-4: Track status to implementation

MOE 1-4-1: Number of recommendations implemented

MOE 1-4-2: Percent increase in Mission Capability (MC)

MOE 1-4-3: Percent increase in Man Hours (MH)

Objective 1-5: Validate utility of Re-Capitalization (RECAP) parts

MOE 1-5-1: Number of successful part implementations

3.1.5.4.2 LTF Analysis: Aviation Logistics Life Cycle management analysis and implementation Goal 2: Increase Readiness

Objective 2-1: Identify 1) Proper utilization of parts (Did we use part as it was intended to be used), 2) Non compliant to specification parts, 3) Inadequate critical characteristics (Inadequate specifications), and 4) Inadequately defined requirements.

MOE 2-1-1: Number of actionable bad parts

Objective 2-2: Identify inadequate Techniques and Procedures (Modifications, Special Tools, more efficient procedures, reduce required inspections and test flights)

MOE 2-2-1: Number of actionable techniques and procedures

MOE 2-2-2: Number of Man Hours (MH) reduced per quarter

Objective 2-3: Alert Decision Makers with adequate information to make changes to Techniques and Procedures

MOE 2-3-1: Number of Technical Summary of Findings (TSOF)

MOE 2-3-2: Number of Product Quality Deficient Report (PQDR)

MOE 2-3-3: Number of Test Incident Report (TIR)

MOE 2-3-4: Number of 2028s (Recommendations to change a reference material)

Objective 2-4: Track status to implementation

MOE 2-4-1: Number of recommendations implemented

MOE 2-4-2: Percent increase in Mission Capability (MC)

MOE 2-4-3: Percent increase in Man Hours (MH)

Objective 2-5: Validate utility of Re-Capitalization (RECAP) parts

MOE 2-5-1: Number of successful part implementations

3.1.5.4.3 LTF Analysis: Aviation Logistics Life Cycle management analysis and implementation Goal 3: Safety

Objective 3-1: Identify 1) Proper utilization of parts (Did we use part as it was intended to be used), 2) Non compliant to specification parts, 3) Inadequate critical characteristics (Inadequate specifications), and 4) Inadequately defined requirements.

MOE 3-1-1: Number of actionable bad parts

Objective 3-2: Reduce "Risk of" injuries and damaged equipment

MOE 3-2-1: Probability of injury and or damaged equipment

Objective 3-3: Alert Decision Makers with adequate information to make changes to Techniques and Procedures

MOE 3-3-1: Number of Technical Summary of Findings (TSOF)

MOE 3-3-2: Number of Product Quality Deficient Report (PQDR)

MOE 3-3-3: Number of Test Incident Report (TIR)

MOE 3-3-4: Number of 2028s (Recommendations to change a reference material)

Objective 3-4: Track status to implementation

MOE 3-4-1: Number of recommendations implemented

MOE 3-4-2: Percent increase in Mission Capability (MC)

MOE 3-4-3: Percent increase in Man Hours (MH)

Objective 3-5: Validate utility of Re-Capitalization (RECAP) parts

MOE 3-5-1: Number of successful part implementations

3.1.5.5 LTF Analysis: Synergistic Testing

Synergistic testing consists of a number of add on programs that support LTF as well as other organizations which test equipment for the aircraft fleet. The process consists of 1) Customer Requests Test, 2) ATTC Analysis of support to LTF Mission (Possible 2nd or 3rd order

effects – Does this fit LTF Mission) Include: Schedule, Maintenance, Down time, Flight Limitations, Personnel support, Resources), 3) ATTC Analysis of Impact on ATTC LTF Mission, 4) ATTC Recommends Accept or Decline synergism test, 5) Funding: Customer pays everything but flight hours. Some examples of this testing:

M48 LIGHTWEIGHT MOTOR BLOWER for the AH64A
The M48 (lightweight motor blower (LWMB)) system is being developed by the Program Manager-Soldier Biological Chemical Command (SBCCOM) for the AH-64 aircraft. The system has undergone testing of several different mounting configurations, culminating in this test to conduct flight compatibility testing of the system with the LWMB mounted to the outside of the crew seat armor plating on the left side of the aircraft. Every effort will be made to use test subjects representative of the 5th percentile female and 50th and 95th percentile male U.S. Army aviator anthropometric measurements for height and weight. In order to fit the anthropometric percentiles as closely as possible, it will be necessary to go outside the U.S. Army Aviation Technical Test Center (ATTC) for participants to fit these parameters.
GEARBOX VIB ANALYSIS for the AH-64A
The U.S. Army Aviation and Missile Command (AMCOM) Test and Evaluation Management Office (TEMO) requested, through the U.S. Army Developmental Test Command (DTC), that the U.S. Army Aviation Technical Test Center (ATTC) support intermediate gearbox vibration testing on the Lead-the-Fleet (LTF) AH-64A helicopter. The data provided to AMCOM TEMO during this test will be used to research the aircraft usage spectrum effects on gearbox vibration levels. On 28 January 2003, DTC directed ATTC to provide the required support. The objective of this test is to collect and provide intermediate gearbox vibration data to AMCOM TEMO.

Chapter 4 ORCEN Recommendations

4.1 ORCEN Recommendations

If the final ORCEN out brief to LTF on May 25, 2004, the ORCEN recommended continuation of the following:

1) Complete and publish Business Plan (Appendix B) NLT 31MAY04

2) Define key terms:

a) Define "Date Format" per Common Logistics Operating Environment (CLOE) data standards.

b) Condition Based Maintenance Plus (CBM+) – Recommended definition CBM+ is a form of proactive equipment maintenance that forecasts incipient failures based on reliability analysis.

c) Observation: Raw data or combination of raw data elements to infer a flight maneuver.

d) Sampling Rate: 4 Hertz or 6 Hertz – The lowest sampling rate which accurately determines the flight maneuver.

e) Sample Size: Number of maneuvers per mission profile, or normalized number of maneuvers per hour/day/month.

3) Adopt LTF Analysis including: 1) Usage Based vs. Time Based Maintenance (Road to CBM+), 2) Aviation Sustainment Analysis, 3) Digital Source Collection (Health Usage Monitoring), 4) Aviation Logistics Life Cycle management analysis and implementation, and 5) Synergistic Testing - Value Added Testing for Project Managers

4) ATTC requires engineering top down focus rather than bottom up recommendations.

5) LTF requires better "forcing function" than just waiting for parts to break. Recommend fatigue analysis, stress analysis and tear down analysis to help build data based linkage between part failure and usage data.

6) Stream line data collection process using all available digital source collectors (DSC) and collect a minimum of 95% of available data using an automated wireless collection process.

7) LTF develops and implements data analysis process to enable CBM+ and logistics prognostics.

8) Think out of the box for CBM+ sensor technologies including: vibration, HUMS, infra-red, ferrography, laser, eddy current, acoustic, and spectrum analysis. Look at the air force Joint Strike Fighter (JSF) as an example of current trends in CBM+ technologies and methodologies.

9) Define CBM+ logistic prediction tool for forecasting. Recommend we know we have enough data when:

a) AED supports transition to CBM+

b) Predict correct overt failure with in 5% of forecasting

c) Ability to correctly classify next "sample" 99% of the time

d) Forecast needed parts with 95% accuracy.

10) Ensure DSC has an aircrew alerting capability when equipment operation conditions impact flight safety.

11) Add AV Task Force, CLOE, CBM+ advisory group, and Army Diagnostic Improvement Program (ADIP) to LTF team to encourage engineering growth and development for CBM+.

12) Get end user involvement. LTF must sell product to field and have crew chiefs and maintainers believe in system prior to fielding.

13) Adopt LTF Engineering Methodology with Aviation Engineering Directorate (AED) with-in the data evolution cycle (Figure 3):

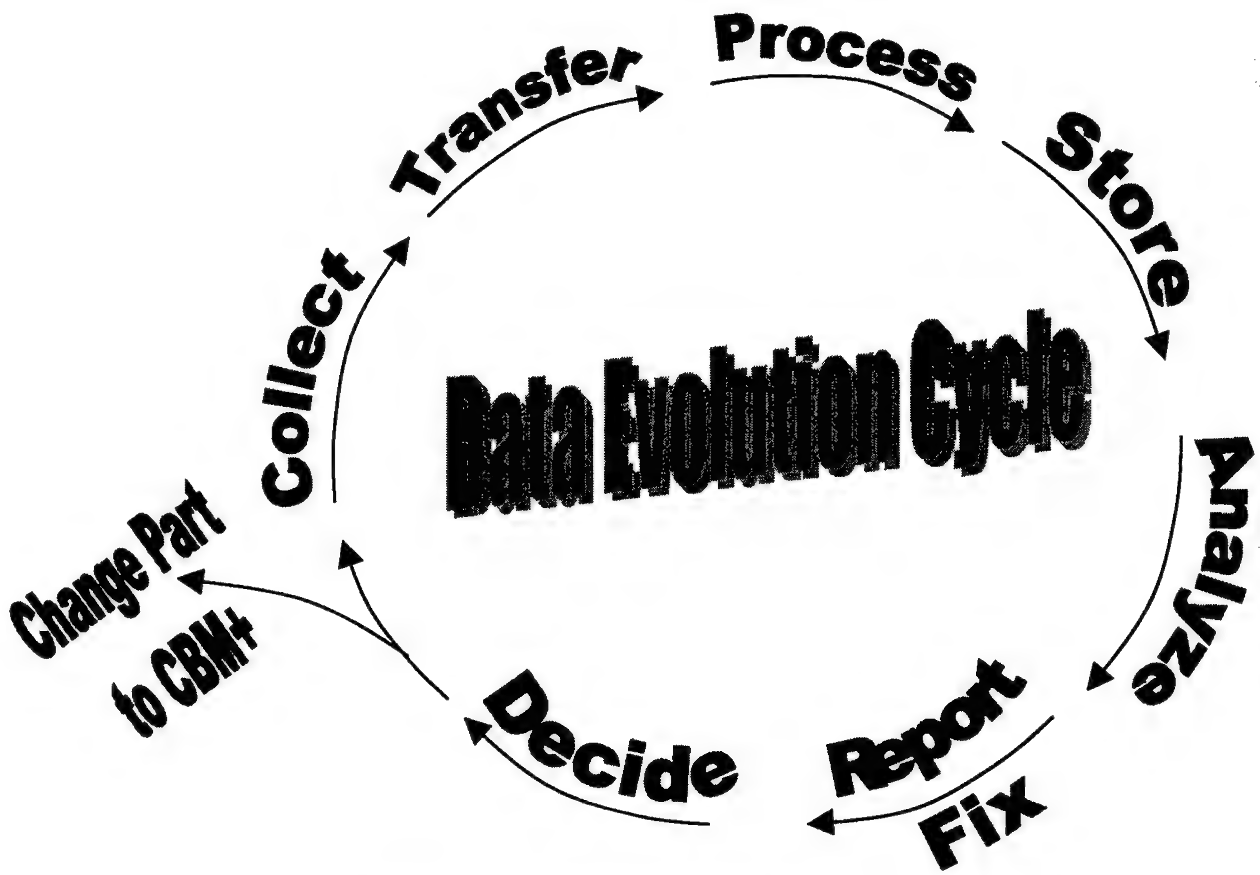

Figure 3: LTF Data Evolution Cycle

4.2 ORCEN Recommendations on things to stop

The ORCEN also recommending the following things to stop:

1) N sample analysis. The sample size should be based on data not aircraft or time. LTF can leverage current fielding of UH-60 HUMS and OIF AH-64 aircraft to help increase data sample size and data collection.

2) 25 aircraft (5 aircraft at 5 locations) is no longer relevant.

3) Length of "Phase 2" depends on adopted Engineering Methodology – not on currently tracked metrics.

4) Phase definitions are no longer relevant with increase in fielded aircraft flying with DSCs installed. LTF must harness this additional data collection and add to existing data collection efforts.

5) ATTC OPTEMPO. LTF must rethink the rational of flying at two times the OPTEMPO of the field. LTF needs to fly ten times as hard, not necessarily two times as long in order to predict sustainment issues prior to fielded aircraft.

6) Eliminate environmental testing with ATTC aircraft due to high cost and minimal benefit unless required for specific part analysis.

The above recommendations were presented to the LTF executive committee on May 25th, 2004. The executive committee took several notes and will implement several of these recommendations into the LTF program.

Chapter 5 ORCEN Future Study

The Lead-the-Fleet program offers several opportunities for future study. This large program is funded through 2010 and will require outside assistance in order to achieve their objectives. The ORCEN is uniquely positioned as an independent research specialist to provide expert support to the LTF program including providing systems engineering analysis, a full-time analyst dedicated to supporting LTF, statistical and analytical research, and providing leadership guidance and analysis for the LTF program. Future ORCEN specific studies may include:

1) CBM+ Systems Engineering Research and Design of Experiments (DOE)

2) Data Mining and Cluster Analysis for CBM+

3) Reliability study to determine the validity of flying at two times the Army OPTEMPO

4) Data Analysis of flight regime data with OEM data to help link usage to part fatigue/failure.

Directed by LTF the future of aviation maintenance includes Integrated Electronic Technical Manuals (IETMs) that update themselves as usage and condition data drives changes to maintenance intervals or processes. Condition becomes the measurable effects of usage, corrosion (environmental effects), manufacturing techniques, materials, specifications, vibrations, and even pilot-induced wear. Inspections are data driven instead of driven by hours flown or calendar time periods. Usage becomes a measured, objective history of how the aircraft is flown. Time Between Overhaul (TBO) items will be converted to condition-based items based on data and fatigue life-limited parts will become condition-based items based on usage data.

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List of Abbreviations

2LM	Two Level Maintenance
AAA	Army Audit Agency
AED	Aviation Engineering Directorate
AMC	Army Material Command
AMCOM	Aviation and Missile Command
AMRDEC	Aviation and Missile Research, Development, and Engineering Center
ARL	Army Research Lab
ATEC	U.S. Army Test and Evaluation Command
ATTC	Aviation Technical Test Center
BLOB	Binary Large Object
BLOS	Beyond Line of Sight
CA	Cost Avoidance
CBA	Cost Benefit Analysis
CBM	Condition-Based Maintenance
CCAD	Corpus Christi Army Depot
CECOM	Communications and Electronics Command
CLOE	Common Logistics Operating Environment
C-MIGITS	Coupled Miniature Integrated Global Positioning System/Inertial Navigation System Tactical System
CONUS	Continental United States
COP	Common Operating Picture
COR	Contracting Officer's Representative
CTS-A	Common Transition System-Army
DA	Department of the Army
DA Pam	Department of the Army Pamphlet
DataMARS	Data Monitor, Analysis, and Reporting System
DCD	Directorate of Combat Developments
DCSLOG	Deputy Chief of Staff for Logistics

DLA	Defense Logistics Agency
DoD	Department of Defense
DSC	Digital Source Collection/Collectors
DTC	Developmental Test Command
DTIC	Defense Technical Information Center
EDRS	Electronic Deficiency Reporting System
ELAS	Enhanced Logbook Automation System
EMA	Essential Maintenance Actions
FDSC	Failure Definition Scoring Criteria
FGC	Functional Group Code
FHC	Field/High/Centerline
FMC	Fully Mission Capable
FMECA	Failure Mode, Effects, and Criticality Analysis
FRB	Failure Review Board
FSR	Fatigue Substantiation Report
GAG	Ground-Air-Ground
GPS	Global Positioning System
HQDA	Headquarters, Department of the Army
HUMS	Health Usage Monitoring System
IETM	Integrated Electronic Technical Manual
IMMC	Integrated Materiel Management Center
INS	Inertial Navigation System
IPT	Integrated Product Team
LIDB	Logistics Information Database
LOGSA	Logistics Support Activity
LOS	Line of Sight
LTF	Lead The Fleet
MAF	Mission Affecting Failures
MDS	Model, Designation, and Series
MFT	Maintenance Flight Time

MMH	Maintenance Man-Hours
MOUT	Military Operations in Urban Terrain
MTF	Maintenance Test Flight
MWO	Modification Work Order
NAVAIR	Naval Air Systems Command
NLOS	Non-line of Sight
NRTC	National Rotorcraft Technology Center
NVESD	Night Vision and Electronic Sensors Directorate
O&S	Operations and Support
ODCS	Office of the Deputy Chief of Staff
OEM	Original Equipment Manufacturer
OPTEMPO	Operational Tempo
ORCEN	Operations Research Center
ORCEN	Operations Research Center
OSMIS	Operating & Support Management Information System
PEO	Program Executive Office
PLL	Prescribed Load List
PM	Preventive Maintenance
PM	Program Manager
PQDR	Product Quality Deficiency Report
QDR	Quality Deficiency Report
RAM	Readiness, Availability, and Maintainability
RAMS	Reliability, Availability, and Maintainability Safety
RCM	Reliability-Centered Maintenance
RCOE	Rotorcraft Center of Excellence
RITA	Rotorcraft Industry Technology Association
RSOU	Relative Severity Of Usage
SA	Situation Awareness
SDC	Sample Data Collection
SE	Systems Engineering

SEDD	Sensor and Electron Devices Directorate
SEDP	Systems Engineering Design Process
SFDLR	Stock Funded Depot Level Reparable
TBO	Time Between Overhaul
TBP	To Be Published
TCOR	Technical Contracting Officer's Representative
TDS	Tangible Dollar Savings
TIR	Test Incident Report
TM	Technical Manual
TRADOC	Training and Doctrine Command
TSOF	Technical Summary of Findings
UAV	Unmanned Aerial Vehicle
UGS	Unattended Ground Sensor
UGV	Unattended Ground Vehicle
UK	United Kingdom
ULLS-A	Unit Level Logistics System-Aviation
UniRAM	Unified Readiness, Availability, and Maintainability
USASC	U.S. Army Safety Center
USMA	U.S. Military Academy
USMA	United States Military Academy
V&V	Verification and Validation
VDLS	Visual Data Library System
VMEP	Vibration Monitoring Enhancement Program
VTOL	Vertical Take Off and Landing
WAR	Weekly Activity Report
WG	Working Group
WUC	Work Unit Codes

Appendix A: Executive Summary – LTF Business Plan

5.1 Purpose and Scope.

Lead the Fleet (LTF) is an innovative program designed to identify and solve critical issues with component reliability and sustainment in the aviation fleet before such issues manifest themselves in the operational fleet and degrade readiness in a theater of war. LTF is the only current program that will deliver information to support development of Condition-Based Maintenance (CBM) and Two Level Maintenance (2LM). The Deputy Chief of Staff for Logistics (DCSLOG), G-4, is the program proponent.

LTF has four chartered goals: (1) improve readiness, (2) reduce the rate of growth of Operations and Support (O&S) costs, (3) improve safety and risk management, and (4) contribute to the future logistics systems development for the Army.

5.2 Phase I

In Phase I, the Aviation Technical Test Center (ATTC) at Fort Rucker, AL, operates the sample set of aircraft in carefully selected profiles that are representative of current operational mission profiles and requirements. ATTC flies at an Operational Tempo (OPTEMPO), which is significantly higher than the overall fleet average. The resulting usage and maintenance data are collected and analyzed to support development of changes in materiel, maintenance procedures, flight profiles, or training. Tests are conducted at sites across North America; aircraft are not kept in hangars except for major maintenance. Phase I requirements are validated through FY 10. Phase I began in FY 03 with the first data collection flights conducted in the second quarter. Primary analysis methodologies included regime recognition and fatigue life-limited, critical safety part analysis. We believe the program has paid for itself in cost avoidance and in tangible dollar savings. See page 1-4.

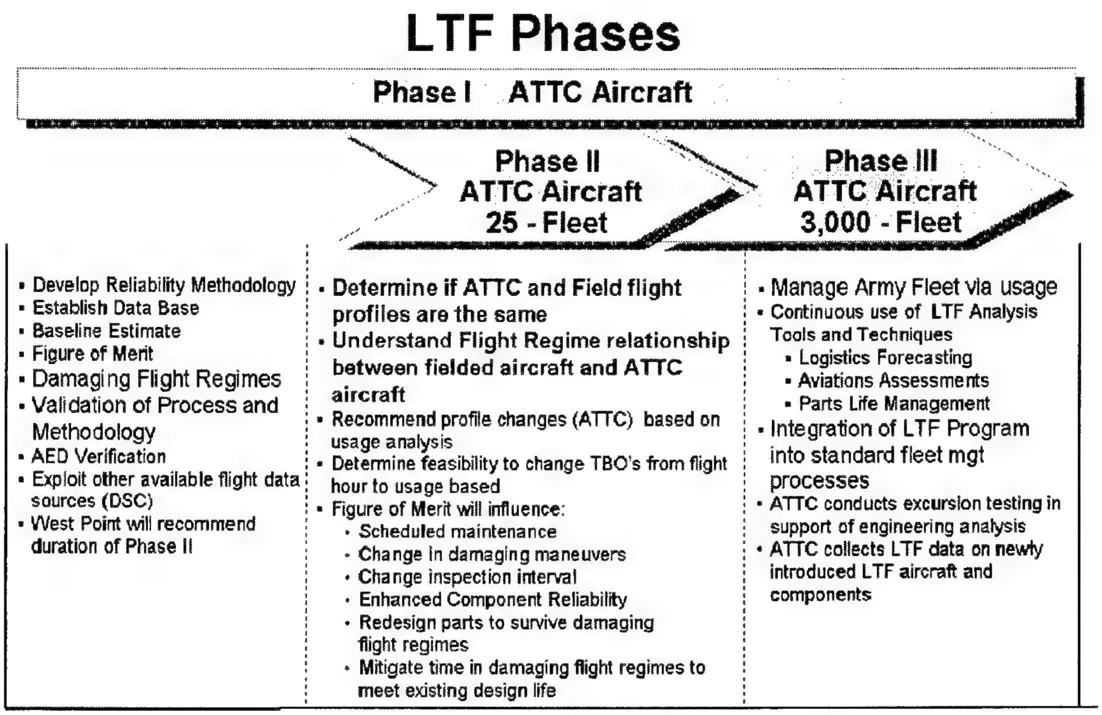

Figure 4: Executive Summary: LTF Phases

5.3 Benchmarks

The benchmarks for LTF are under development. Three examples are of particular interest. The LTF team will continue to research and develop appropriate correlation and knowledge sharing with these potential benchmarks. See paragraph 1.3 Industry Benchmarks. **BMW** has developed Condition-Based Service. On board monitoring systems ascertain the service requirements for each individual vehicle based on usage.

The **United Kingdom** (UK) Ministry of Defense has installed digital source collectors on the UK Chinook Mk2/2A fleet. Since installation, a number of benefits have already been demonstrated: reduction in aircraft downtime, reduction in maintenance actions to diagnose and rectify instrumentation faults, reduction in maintenance actions to identify faulty components, and a reduction in fleet down-time through use of the DSC device to perform urgent unscheduled checks of a suspect component on an aircraft.

The **U.S. Navy** has developed Reliability Centered Maintenance (RCM), as an analytical process used to determine PM requirements. Currently, all new Naval Air Systems Command (NAVAIR) acquisition and major modifications incorporate RCM.

5.4 Processes.

The LTF team has completed the first draft of the business process definition. The group used an accepted process engineering approach called Activity Definition Modeling. The team has identified the principal activities, required inputs and outputs, constraints, the contributing agencies, and the roles and responsibilities of each member of the team. The resulting process diagrams will be added to this business plan as an appendix. The business process definition included agencies, which offer contributions in the form of collaboration, expertise, or funding.

5.5 Current Analytical Methodologies.

Phase I has relied upon regime recognition algorithms. The captured data is compared against original equipment manufacturers design data to determine accumulated wear as a percentage of the design life. The regime recognition program is written in C++ and was designed to be entirely autonomous.

5.6 Products and Deliverables.

The LTF team identified each deliverable and product for each activity in the business process model. A deliverable describes an output, which is required for the next activity in the process. These items include Quality Deficiency Reports, Technical Incident Reports, and Technical Summary of Findings. The Team interprets Products as having obvious value to the Army. Products to date include time saving changes to maintenance procedures, improved materials, labor-saving modifications to the aircraft, and changes to the technical manuals which will enhance reliability and maintainability. See page 1-4 and Chapter 5.

5.7 Metrics and Reporting.

The G-4 requested that LTF use four metrics: Readiness, O&S cost Avoidance, Safety, and Documented Failures. Ms. Modell Plummer, the G-4 Director of Sustainment, has asked the Army Audit Agency to validate the metrics. The AAA findings are expected in late summer. The metrics are: 1) Readiness is measured in hours of downtime avoided by enhanced maintenance procedures, unnecessary parts replacement, or additional availability; 2)

O&S Cost avoidance is measured in dollars to allow normalization between maintenance man-hours and actual costs of repair; 3) Safety is measured in dollars of cost avoidance from materiel not damaged or destroyed; and 4) Documented Failures is the rate that the LTF team identifies and reports failures compared to the overall fleet.

5.8 Governance.

The LTF program requires three levels of oversight for maximum effectiveness.
The Executive Steering Committee provides strategic direction, assists with funding, ensures communication within their respective organizations, and provides feedback to the Leadership Team and the Working Group. A G-4 representative will chair the ESC.
The Leadership Team is chaired by the AMRDEC PM. This body is charged with program execution, compliance within funding constraints, and to assist with prioritization of resources. The team provides feedback to the Working Group and ensures consistent communications within their respective organizations.

The Working Group manages all daily operations of LTF, produces each deliverable and product on time, and prepares reports and briefings as required.

5.9 Other Potential Synergies.

5.9.1 Value added testing.

The LTF project provides an opportunity for conducting Value Added (VA) testing using one or more of the LTF aircraft. The aircraft PMs (PEO, Aviation) frequently utilize this "piggyback" capability. The PM funds any additional cost or work outside the scope of scheduled LTF testing. Work done for the PMs within this concept would normally be unfunded. The LTF aircraft are available for both ground and flight test on a minimum impact basis.

5.9.2 CBM and 2LM development.

The Army's Logistic Transformation envisions maintenance operations based on condition and usage. When required, maintenance will be conducted within a two-tier system

characterized by "replace forward and repair rearward." Lead the Fleet is the only program furnishing objective data to assist in this transition.

5.9.3 Other Major Weapon Systems.

LTF uses a systems approach that can be tailored to identify and proactively solve sustainment issues with any major weapons program. The LTF program will directly address the Army G-4 Common Logistics Operating Environment (CLOE) initiative for synchronization of sustainment and technology.

5.9.4 Educational Centers of Excellence.

On 6 September 2000, the National Rotorcraft Technology Center awarded 5 Year grants to three universities: Georgia Institute of Technology, the University of Maryland, and the Pennsylvania State University. The three grants total $2.3M. LTF will facilitate the use of these centers to develop required forecasting, data management procedures, material enhancements, and required CBM/2LM transition processes.

5.10 The Bottom Line.

Lead the Fleet is a systems approach to proactively solving sustainment issues based on equipment condition and planned usage in theater. In the future, sustainment packages could be tailored to each weapon system based on forecasts of required skills, parts, and time … all driven by required system availability.

The program is critical to Aviation Logistics Transformation and to the Army's successful transition to Condition Based Maintenance and 2 Level Maintenance. The program will utilize industry best practices for reductions in the O&S cost growth and continue to provide a return on investment commensurate with its overall value to the Army.

Appendix B: LTF Business Plan

Table of Contents

Appendix B (Pgs B1-B65) = Report Pgs 37-101

List of Figures

List of Tables

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Appendix B (Pgs B1-B65) = Report Pgs 37-101

Lead the Fleet Business Plan Working Draft

1.0 Purpose and Scope

1.1 Mission, Purpose, and Goals

Lead the Fleet (LTF) is an innovative multi-year program designed to identify and solve critical issues with component reliability and sustainment in the aviation fleet before such issues manifest themselves in the operational fleet and degrade readiness in a theater of war. LTF is an innovative program beneficial to the Warfighter, Logisticians, and the Army by furnishing objective information to solve difficult readiness and sustainment problems. LTF is the only current program that will deliver information to support development of Condition-Based Maintenance (CBM) and Two Level Maintenance (2LM). The Deputy Chief of Staff for Logistics (DCSLOG), G-4, is the program proponent.

In Phase I, the Aviation Technical Test Center (ATTC) at Fort Rucker, AL, operates the sample set of aircraft in carefully selected profiles that are representative of current operational mission profiles and requirements. ATTC flies at an Operational Tempo (OPTEMPO), which is significantly higher than the overall fleet average. The resulting usage and maintenance data are collected and analyzed to support development of changes in materiel, maintenance procedures, flight profiles, or training. Tests are conducted at a variety of sites from Duluth, MN, to El Centro, CA, and the southeastern United States to ensure realistic environmental effects. The aircraft are not kept in hangars except for extended maintenance and severe weather warnings. Supporting maintenance is compliant with current Department of the Army (DA) standards.

In Phase II, data collection will expand to selected aircraft operating in the field on a non-interference basis. Adding operational data collection is a critical step in supporting the transition to CBM.

Goals

LTF has four chartered goals:

1. Improve readiness.
2. Reduce the rate of growth of Operations and Support (O&S) costs.
3. Improve safety and risk management.
4. Contribute to the future logistics systems development for the Army.

Readiness describes the ability for a given system or unit to conduct sustained operations in a specified theater. The most powerful contribution of LTF should be the ability to proactively understand theater environmental effects on fatigue and condition. Potential LTF contributions include forecasting advice to build sustainment packages that would include (relevant for the planned theater of employment) skills, parts, and tools/test equipment.

Information from LTF could be used to calibrate forecasting of required spares by planned OPTEMPO and theater.

Reduced growth rate of O&S costs can be achieved through enhanced resource management and Cost Avoidance (CA). Prescribed Load Lists (PLLs) are traditionally based on demand generated in training but not necessarily in the theater of employment. Applied forecasting will enable theater-based spares management; only relevant repair parts will be moved into theater. CA opportunities include Maintenance Man-Hour (MMH) reductions, safety parts qualification, realistic testing of material improvements within components, and forecasting assistance for procurement.

From the U.S. Army Safety Center (USASC), "Army safety activities are organized to protect the force and enhance warfighting capabilities through a systematic and progressive process of hazard identification and risk management."

"Risk Management is the process of identifying and controlling hazards to protect the force." Risk is managed in a closed-loop five-step process. LTF can contribute to each of the steps.

1. Identify the hazards – aggressive OPTEMPO flying in mission profiles will cause many failures to occur in the sample before manifestation in the fleet.

2. Assess the hazards – LTF engineers, in cooperation with the Aviation Engineering Directorate (AED), are able to infer and analyze risks. AED is uniquely qualified (Army Aviation's airworthiness release authority) to assess hazards discovered during LTF activities.

3. Develop controls and make decisions – LTF leads a collaborative community of interest, which includes the USASC, AED, ATTC, the Integrated Material Management Center (IMMC), the aircraft PMs, and others. This cooperative body has the experience and the responsibility for such decisions within Army Aviation.

4. Implement controls – the collaborative body supporting LTF has responsibility for material fielding. LTF provides a powerful objective management system for implementing change.

5. Supervise and evaluate – LTF is uniquely positioned to collect data and information after resolution implementation. Phase III of LTF envisions sufficient Digital Source Collection (DSC) capability to measure the effect of any fielded change.

Purpose

LTF will provide significant value to Warfighters, logisticians, and maintainers, and to the Army by increasing operational capability, streamlining maintenance, and enhancing readiness.

Value to Warfighters
Using ATTC's test capabilities, LTF can rapidly validate and qualify warfighting requirements specific to a theater of war. The sustainment implications of those requirements can be measured and mitigated through carefully developed changes in flight maneuvers, training, maintenance, or other sustainment procedures. ATTC has concluded a rigorous test of the impacts on fatigue life as a result of AH-64 diving fire and extreme maneuvering flight required for survivability in Iraq. Such testing increases crew confidence in how the aircraft will respond in unfamiliar theaters or environments.

Value to Logisticians and Maintainers
As the Army develops CBM, such testing will support enhanced forecasting of sustainment requirements in theater, rather than relying on demand history developed during Continental United States (CONUS) or home-based operations. This concept of battle-focused spares management will ensure that scarce transportation requirements are used for relevant sustainment materiel. Higher reliability will result due to anticipation of maintenance issues and the development of the required solutions in a proactive, deliberate methodology. Scheduled maintenance becomes more relevant to a theater; unscheduled maintenance will be reduced due to improved forecasting as the Army moves to prognostic behaviors. LTF will provide objective data to support development of CBM and 2LM. Aircraft Program Mangers (PMs) will enjoy early warning of premature component failures and support for solution development. Over the next five years, inspections could be tailored to each aircraft based on condition, usage, theater, threat levels, and flight profiles.

Value to the Army
LTF will enhance readiness, reduce the rate of growth of O&S costs, and enhance the Army's operational risk management. LTF identifies and resolves readiness issues before they are manifested in a theater of war. Additional CA will be achieved through a reduction in MMHs required for scheduled maintenance. The LTF team has completed design and testing of a special tool for the CH-47. When used during replacement of the drive link bearings, the tool will save 18,000 man-hours per annum. This is approximately 9 man-years.

LTF collects valuable information to support the transition of aviation maintenance from calendar time and hours flown to a condition and usage basis called CBM The G-4 has designated LTF as a pilot program for data collection and information development in support of the Army's transition to CBM. Information produced may also prove useful in supporting the analysis and development of 2LM.

LTF has already made a significant contribution to risk management. The LTF team identified excessive, accelerated wear on AH-64 pitch change links during the high OPTEMPO operations. The rate of wear in a single flight period had potential for catastrophic failure. The findings resulted in the item manager pulling 2,000 substandard parts out of the distribution system.

1.2 Expected contributions to readiness by phase

The LTF Program has three major phases for budget planning and execution. This perspective enables budget programmer and managers to look at approximate cost and value by those funding periods.

From a test management perspective, LTF is a carefully correlated set of experiments, studies, and analyses designed to provide some short-term value to the Army. More interesting long-term value will come from objective, high quality data, which when transformed into information, becomes the basis for CBM.

Phase I

Phase I (FY03 – FY10) began in FY 03 with the LTF first flights conducted in May 2003. Primary analysis methodologies included regime recognition and fatigue life-limited, critical safety part analysis. We believe the program has paid for itself in CA and some Tangible Dollar Savings (TDS). In Table 1.2.1, the G-4 directed metrics suggest the following value:

Table 1.2.1. Phase I Contributions

Category	Finding	Actual	Potential	Period
Readiness MMH is maintenance man-hours	AH64 Nozzle Mod CH47 Special Tool AH64 PCL Bearing	135,000 MMHs	4400 MMH 19,000 MMH 2.3% OR	Annual Annual 1 time
O&S	AH64 Nozzle Mod CH47 Special Tool AH64 PCL Bearing		\$1.6M CA \$2.5M CA \$14.2M TDS	1 time Annual 1 time
Risk Reduction	AH64 SDC Filter PCL Bearing		\$15.5M CA \$17.7M CA	1 time 1 time
Event Documentation	Cat I or II QDRs submitted from LTF events	LTF documents 10 times as many component or part failures as the operational fleet	Based on rate per 1000 hours flown	Annual

Phase II (FY 06 – FY 11) will serve as the transition to full implementation of CBM and perhaps 2LM in Phase III. Phase II imperatives include developing processes to convert maintenance management from hours flown and calendar time to condition and usage. The LTF team has developed a list of critical hypotheses to test and answer in Phase II so that the Army is well positioned to implement CBM in the aviation fleet.

Phase II Categories for Research and Testing
The following list is not all-inclusive but serves as the framework for Phase II. The questions are grouped into three categories: Sampling Validation for Phase I, Phase II Analysis, and Phase II Infrastructure. All questions refer to work that will be accomplished in Phase II.

Phase II Sampling validation:

1. How do we ensure that flights conducted by ATTC are representative of actual operational usage of the aircraft by Model, Designation, and Series (MDS)? What are the metrics to track this?
2. What is failing and why?
3. What are the cost drivers for readiness, O&S costs, and risk management by MDS?
4. What are the unique capabilities developed within LTF that can be exploited to other weapon systems?
5. How will we save money and reduce the rate of growth of O&S costs?

Phase II Analysis:

1. What are the best data analysis methodologies to use in Phase I and II as we develop the data-driven capability for the CBM concept?
2. Given how the Army employs the aircraft today, what is the relevance of the design and test data published by the Original Equipment Manufacturer (OEM) for use as a fatigue life-limited, critical safety part analysis?
3. What are the alternative methodologies for measuring wear and producing on-condition change criteria?
4. What data are required to maximize the contribution and capability of the DSCs to understanding transformation to CBM?
5. What is the required lead time for condition-based conclusions and forecasting to enable logisticians to put required materiel in theater?
6. What is the best analytical methodology to forecast part and component consumption to support a required availability in a theater?
7. What is the best analytical methodology to forecast part and component change out based on actual condition of the component or part?
8. Are RECAP components installed on the LTF sample meeting Army expectations?

Phase II Infrastructure:

1. What are the preferred consistent methods and data flows for collecting, processing, storing, and sharing data obtained from the Army's DSCs?
2. How do data collection, processing, storage, and sharing fit within the Common Logistics Operating Environment (CLOE)?
3. What is the design architecture and required tool set to maximize the value of the target data repository for operating CBM?
4. What is the best process to recover from a loss of data at each of the nodes in the data flow process?
5. What synergies can be developed from DSC, CBM, and enhanced Unit Level Logistics System-Aviation (ULLS-A)?

Phase III Support Implementation of CBM
The full vision of CBM implementation is under development by the Deputy Chief of Staff, Logistics (DCSLOG), G4. Based on open source documentation, the LTF team has attempted to describe the maintenance operating environment in 2010 and beyond. Although the team has DA civilian, active military, and other subject matter experts, this view of Phase III is an educated guess. The LTF team will meet with G4 representatives in early May to further develop this vision.

1.3 INDUSTRY BENCHMARKS

By the year 2010, Logistics for the Future Force will be primarily characterized by a global reach construct as requirements; platforms, weapons system support, and readiness management assume a global focus. In addition, the Army will exploit emerging technologies to lighten support requirements, project forces faster, and change sustainment requirements. The Army will use these emerging technologies to establish CBM as a new framework for logistics support. LTF will establish the Systems Engineering framework for Army Aviation CBM.

CBM is a broad-based maintenance concept intended to predict equipment failures based on real-time or near real-time assessment of equipment condition obtained from embedded sensors, external tests, and measurements using portable equipment. The intent of CBM is to reduce maintenance down-time and increase operational readiness by repairing or replacing system components based on the actual condition of the component as opposed to other maintenance concepts, such as scheduled or time-phased maintenance procedures.

Predictive versus reactive logistics
CBM adds two important dimensions to predictive maintenance. First, CBM deals with the entire system as an entity. This holistic approach to maintenance represents a major shift from the piecemeal methodologies of the past. The second dimension is the concept of ignoring or extending maintenance intervals. Current predictive trending techniques use historical data to confirm maintenance decisions that are based on expert opinion. Due to its systemic approach and trend analysis, CBM will give the aviation logistician a basis from which to make fact-driven maintenance decisions.

Major interest in "on-line" component monitoring and a systemic CBM approach began to appear in industry in the early 1990s, and recent innovations by the car manufacturer BMW illustrate CBM. BMW's Condition-Based Service ascertains the service requirements for each individual vehicle. Condition Based Service monitors wear-and-tear on critical automotive components. On-board sensors determine when a component is replaced or upgraded. Even if the degree of wear is not gauged directly, the system uses algorithms to determine when a service check-up is required. Information about the automobile is saved on the car key and downloaded to the diagnostic equipment. The new BMW 7 series will feature wireless data transferal from the car to the dealer.

With CBM as a future goal, the United Kingdom (UK) Ministry of Defence installed a DSC device on the UK Chinook Mk2/2A fleet. This system has over one million flight hours of

operation in numerous helicopters operating over the North Sea. In the brief time since the installation of the DSC devices, a number of benefits have already been demonstrated:

- Reduction in aircraft downtime through accurate recording of exceedances, as opposed to reliance on the aircrew perception.
- Reduction in maintenance actions to diagnose and rectify instrumentation faults.
- Reduction in maintenance actions to identify faulty components.
- Reduction in fleet down-time through use of the DSC device to perform urgent unscheduled checks of a suspect component on an aircraft.

The DSC device and archived data were used to check the entire UK Chinook fleet in a fraction of the time it would have otherwise taken through traditional methods, such as component removal and inspection, which is the current U.S. Army method.

Preventive Maintenance (PM)
Most major airlines have adopted CBM, as well as Reliability Centered Maintenance (RCM), a maintenance concept recently adopted by the U.S. Navy. The U.S. Navy defines RCM as an analytical process used to determine PM requirements. Currently, all new Naval Air Systems Command (NAVAIR) acquisition and major modifications incorporate RCM. Prognosis and Health Management systems are used to monitor equipment condition and provide indications to the operator or maintainer. The primary objective of the RCM process is to identify ways to avoid or reduce the consequences of failures, which, if allowed to occur, will adversely affect personnel safety, environmental health, mission accomplishment, or economics. This is the product of a Failure Mode, Effects, and Criticality Analysis (FMECA). The effort and priority given to determining an appropriate method for reducing the consequences of failure to a level that is acceptable to the end item user depends on the severity of the failure consequences. For example, a failure whose consequences result in a hazardous situation to personnel takes precedence over a failure that affects only economics.

PM is only one way that failure consequences can be mitigated. While a PM task should be implemented when it is appropriate to do so, it might not be the best solution in all cases. For example, the RCM analysis might indicate that the best solution is simply to allow the failure to occur, then perform corrective maintenance to repair it. In other instances, analysis might indicate that some other action is warranted, such as an item redesign, a change in an operational or maintenance procedure, or any number of other actions that will effectively reduce the consequences of failure to an acceptable level.

1.4 STEADY STATE – HOW WILL THE PROGRAM LOOK AT STEADY STATE OPERATIONS

LTF is currently building ever more robust capabilities in Phase I of its life cycle. Phase III should fully support the fielding and operational capability of CBM. Phase II must support transition from the current Phase I posture to the envisioned Phase III "Steady State."

To ensure relevance of Phase II, the LTF team conducted a strategic planning exercise on 9 April 2004 to envision some of the potential of CBM and how Phase III of LTF could support that final "steady state." The team used the year 2010 as the first year of steady state CBM operations. In the year 2010, CBM could have the following characteristics:

Operational Capability
- We will proactively manage maintenance to yield required aircraft availability in theater.
- Unscheduled maintenance will occur due only to battle damage, random failures, or exogenous factors.

Sustainment
- Logisticians anticipate sustainment requirements by theater based on usage.
- Analysts empirically validate anticipatory sustainment requirements by theater.
- All maintenance will be conducted before failure and as required due to conditions such as wear, vibrations, combat damage, foreign object damage, accidents, corrosion, and hangar rash.
- There will be continuous improvement of anticipated sustainment requirements.
- Post-deployment recovery requirements will be forecast for programs like RESET, recapitalization, and national maintenance points.
- There are automated logistic responses as failure trends are detected in the data.

Maintenance Processes
- There are Integrated Electronic Technical Manuals (IETMs) that update themselves as usage and condition data drives changes to maintenance intervals or processes.
- Condition becomes the measurable effects of usage, corrosion (environmental effects), manufacturing techniques, materials, specifications, vibrations, and even pilot-induced wear. Inspections are data driven instead of driven by hours flown.
- Usage becomes a measured, objective history of how the aircraft was flown.
- Time Between Overhaul (TBO) items will be converted to condition-based items based on data.
- Fatigue life-limited parts will become condition-based items based on usage data.
- Condition change items will remain so; component removal is based on data.

Infrastructure
- Each aircraft has DSC.
- DSC includes data from the electronic logbook.
- Data are automatically shared between multiple databases.
- Remote diagnostics will enable extremely efficient root cause analysis and support.
- Engineers will remotely monitor data, produce trend analyses, and recommend solutions prior to significant failures.

2.0 Processes

2.1 Agencies Involved, Roles, Functions

Office of the Deputy Chief of Staff (ODCS) G4, Headquarters, Department of the Army (HQDA): G4 sustains the combat readiness of the deployed force and maintains the operational readiness of the current force. The Directorate of Sustainment sponsors the Army LTF Program. The Aviation Logistics Division serves as the single point of contact for Army Aviation logistics concepts, doctrine, policies, plans, programs, and systems within HQDA. The aviation logistics division monitors, evaluates, and affects necessary actions in the Army LTF Program.

Army Material Command (AMC): AMC provides materiel readiness to the Army, including technology, acquisition support, materiel development, logistics power projection, and sustainment. AMC operates the Research, Development and Engineering Centers; Army Research Laboratory; depots; arsenals; ammunition plants; and other facilities, and maintains the Army's prepositioned stocks, both on land and afloat. To develop, buy, and maintain materiel for the Army, AMC works closely with Program Executive Officers, the Army Acquisition Executive, industry and academia, the other Services, and other government agencies.

Aviation and Missile Command (AMCOM): AMCOM serves as the "Army's sustainment manager," keeping supported systems ready to fight. AMCOM supports Program Executive Offices (PEO) and Program Managers (PM) and develops, acquires, and fields Army Aviation and missile systems to ensure the Army's readiness and technological superiority. AMCOM serves as the lead in the Army's foreign military sales. LTF works closely with AMCOM to transition Army from time-based maintenance to CBM. To increase readiness, LTF works closely with IMMC and Corpus Christi Army Depot (CCAD).

<u>Integrated Materiel Management Center (IMMC)</u>: IMMC works with PEOs and PMs, Warfighters, and industry to develop, acquire, field, and sustain worldwide logistic support to ensure the Army's weapon systems readiness.

<u>CCAD</u>: CCAD overhauls, repairs, modifies, retrofits, tests, and modernizes helicopters, engines, and components for all Services and foreign military customers. CCAD serves as the aviation depot training base for active duty Army, National Guard, Reserve, and foreign military personnel. CCAD also provides worldwide on-site maintenance services; aircraft crash analysis; lubricating oil analysis; and chemical, metallurgical, and training support.

Developmental Test Command (DTC): DTC conducts developmental testing of weapons and equipment for the U.S. Army Test and Evaluation Command (ATEC). DTC possesses a diverse array of testing capabilities in the DoD, testing military hardware of every description under precise conditions across the full spectrum of cold weather, tropical, desert, and other natural or controlled environments on highly instrumented ranges and test courses. DTC

works closely with PMs and acquisition executives to support efficient and cost-effective test planning, including streamlining the test program when feasible.

ATTC: ATTC conducts developmental testing of aircraft, aircraft components, aircraft subsystems, and aviation-related support equipment under all climatic conditions, including desert, tropic, and cold weather environments. ATTC evaluates all aspects of performance and handling, as well as airworthiness and flight characteristics evaluations of Army aircraft. ATTC also executes the Army LTF Program, providing a highly experienced cadre of aviators, a nucleus of scientific and engineering personnel, and contractors who support LTF. ATTC aviators fly relatively severe mission profiles at an accelerated OPTEMPO. LTF failure events are entered into a Readiness, Availability, and Maintainability (RAM) data collection and management database for engineering analysis. In addition, ATTC provides a succinct summary of LTF failure events via standardized Army testing, maintenance, logistics, and safety reporting systems.

Aviation and Missile Research, Development, and Engineering Center (AMRDEC): AMRDEC plans, manages, and conducts research, exploratory, and advanced development. AMRDEC also provides one-stop life cycle engineering, technical, and scientific support for aviation and missile weapon systems and their support systems; UAV platforms; robotic ground vehicles; and all other assigned systems, programs, and projects. The Test and Evaluation Management Office of AMRDEC provides program management of the Army LTF Program.

AED: AED serves as the airworthiness authority for Army-developed aircraft and provides matrix support to the PEO for Aviation Programs Project/PMs and AMCOM Defense Systems Acquisition PMs. AED coordinates with ATTC to identify and evaluate potential LTF aircraft discrepancies and failures. AED analyzes the Unified Readiness, Availability, and Maintainability (UniRAM) database to establish safety and logistical trends that result from the rate and severity of LTF operational usage. AED works with the PMs and OEMs to develop engineering changes, solutions, qualification requirements, and maintenance procedures to resolve LTF discrepancies and trends before they adversely impact aircraft in the field.

PEO Aviation: PEO Aviation manages the Apache, Cargo, and Utility Helicopters; Unmanned Aerial Vehicle; and Aviation Systems programs. PEO Aviation provides overall direction and guidance for the development, acquisition, testing systems integration, product improvement, and fielding of assigned programs, with primary management emphasis and oversight on cost, schedule, and performance. Due to the availability of field representative aircraft and systems in the LTF Program for product improvements and integration demonstration, PEO Aviation benefits immensely from the LTF program.

USASC: USASC synchronizes efforts across the Army's major commands and the Army staff during the development and day-to-day management of safety policies. It supports commanders and the Army staff by providing them with timely, accurate hazards, risks, and controls information they can use to make informed risk decisions. LTF shares critical safety

information and findings with USASC. USASC and LTF work together to increase component reliability and improve airworthiness of Army aircraft and aviation systems.

2.2 WORKING GROUP (WG) MEMBERS' JOB DESCRIPTIONS

The information below describes the LTF team composition and its functions to build the products and provide the services necessary to achieve LTF objectives.

Program Manger (PM): LTF PM provides leadership and management to achieve program goals. Responsibilities include: competitive strategy development, marketing plan development and execution, customer contact, proposal development, program plan development, planning, tracking & oversight, scheduling, budgeting, status reporting, customer interfacing. Supports internal and external technical and management reviews, meetings, and negotiations as needed. PM leads and supports program expansion efforts. PM provides technical direction and oversight to the LTF team members.

Deputy PM: Deputy PM provides process and planning advice and expertise to LTF team members across the program cycle. Deputy PM serves as the day-to-day manager of the LTF program and assists the PM in developing and maintaining program budget and administrative requirement. Other responsibilities include: conduct planning, coordinating, and monitoring of the work of contractors and/or Government team members; determine goals and objectives for the LTF program; develop policies, procedures, and project plans to meet these objectives. Deputy PM represents the PM in meetings with high-level management officials of other Army agencies.

Fort Rucker LTF Members:

> Assistant PM (APM): Serves the dual purpose as the Assistant PM of LTF and the LTF Division Chief in Flight Test Directorate (FTD) within ATTC. Provides government representation support to LTF PM in all areas of LTF program, specifically in program management and engineering. Conducts LTF briefings to ATTC visitors. Provides LTF updates to outside agencies as required. LTF POC in AED LTF partnership. LTF POC in West Point LTF project. Provide government representation and engineering coordination. Assists LTF PM with coordination with Rotorcraft Centers of Excellence (RCOEs). Manage ATTC LTF personnel issues to support ongoing LTF program. Manage LTF OPTEMPO. Manage Reliability, Availability and Maintainability Safety (RAMS) engineering and DSC requirement at ATTC to support current and future LTF requirements. LTF Flight Test Director for ATTC. Manage LTF budget. Plan, coordinate, and execute LTF environment off-site testing. Plans, coordinates, and executes urgent Warfighter support testing. As LTF Integrated Product Team (IPT) Lead, assist LTF PM in providing government representation in LTF program. Assists with LTF Technical Summary of Findings (TSOF) process.
>
> Principle Program Integrator: Serves dual purpose as the Principle Program Integrator of LTF program and the assistant division chief of LTF division at ATTC. Responsible for normal administrative requirements of the test team (personnel, office, equipment, etc.). Responsible for internal meetings and briefings. Technical

Contracting Officer's Representative (TCOR) for COBRO data collection efforts and Westar support of LTF. These efforts include all aspects of the contract, hiring, disciplinary actions, travel request, overtime request, etc. Responsible for the day-to-day activities of LTF execution. Act as first-line supervisor. Schedule day-to-day and long-range planning. Responsible for managing the entire LTF budget, including test execution and analysis funding. Primary POC for the Value Added (VA) tests at ATTC. Supports LTF PM in internal and external LTF requirements.

<u>Westar PM</u>: Serves as the Westar PM at ATTC providing guidance and continuity for all Westar employees assigned to ATTC. Provides direct continuity and leadership to Westar LTF team members in Huntsville, AL. Assists the PM in planning, developing, and coordinating the LTF program with detailed knowledge of systems engineering. Assists in developing, editing, and processing LTF TSOF.

<u>Senior Aviation Logistician</u>: Perform logistics oversight of LTF. Coordinate day-to-day readiness and availability issues with the Contracting Officer's Representative (COR)/contractor. Provide technical advice to aircraft maintenance COR. Direct ATTC maintenance contractor priorities for LTF. Coordinate Modification Work Order (MWO) applications both on-site and off-site. Coordinate directly with IMMC/Defense Logistics Agency (DLA)/PMs for parts. Review maintenance practices and techniques to determine effectiveness, and initiate actions to document. Reviews value added test impact in terms of LTF maintenance requirements-assist in test plan formulation. Act as a conduit for any maintenance related issues for or about LTF. Perform initial component failure analysis. Inspect every part that is removed from an LTF aircraft and determine whether component meets the criteria for a Category (CAT) I or CAT II Product Quality Deficiency Report (PQDR). Direct prioritization of PQDRs. Direct the initial PQDR disposition and analysis of components. Direct troubleshooting in support of failure analysis. Review necessary databases (PQDR, Operating and Support Management Information System (OSMIS), Enhanced Logbook Automation System (ELAS), UniRAM, RMIS) to conduct initial investigations. Review the initial analysis of both the PQDR and Test Incident Report (TIR) prior to forwarding. POC to answer technical questions from the AED, PMs, IMMC, Communications and Electronics Command (CECOM), and DLA regarding PQDRs. Follow through with AED, PMs, IMMC, and CECOM, after receiving PQDR responses.

<u>Westar Senior Test Coordinator</u>: Maintains and coordinates all Project Status Reports and files for LTF. Prepare all cost estimates for new LTF projects. Track all funds for the LTF program. Conduct off-site exercises to include site surveys and selection of off-site facilities for LTF environmental testing. Supervises data collection and processing of environmental off-site testing. Coordinates with maintenance personnel on LTF asset availability daily. Coordinates use of LTF aircraft with other test coordinators and test directors for additional tests to be conducted using LTF aircraft. Coordinate all LTF flight schedules to ensure maximum use of aircraft to accomplish LTF mission. Maintain daily status of aircraft readiness posture and flight time reports for LTF assets. Prepare information for LTF hours, Quality Deficiency

Reports (QDRs) and TIRs for the DTC Weekly Activity Report (WAR). Prepare monthly LTF flying hour reports for the ATEC aviation officer.

Westar Software Engineer: Perform routine data processing reduction for aircraft using a DOS batch program and ADAPS disks [for Coupled Miniature Integrated Global Positioning System (GPS)/Inertial Navigation System (INS) Tactical System (C-MIGITS)], and Data Monitor, Analysis, and Reporting System (DataMARS) disks (for DataMARS). Verify collected data and minimize data loss. Troubleshoot and prevent data loss (hardware, software, personnel). Create dynamic charts and reports from the aircraft flights. Track data loss by percentage over time per aircraft. Track C-MIGITS and DataMARS disks for inventory. Develop, maintain, and administer Microsoft Access database for flight profile cards. Run queries and reports against databases (Oracle and MS Access). Create Excel charts and reports from the collected data. Troubleshoot RAM Collector's problems with flight profile cards. Query databases and check tables in Oracle and MS Access. Coordinate with personnel in Huntsville and ATTC to determine errors and fix them. Transfer data from aircraft to Vibration Management Enhancement Program (VMEP) and to the Ground Base Station. Review VMEP indicators for the aircraft and notify proper personnel.

COBRO Project Lead: Assist in determining for which parts/incidents from LTF aircraft TIRs and QDRs are written. Research part/maintenance information using Technical Manuals (TMs), FedLog, UniRAM, etc., in preparation for writing TIRs. Interview/interact with maintenance contractor personnel when maintenance or parts problem/ questions arise. Interact with members of AMCOM, Westar/Huntsville, and other agencies to perform data queries and solve problems as necessary. Write TIRs. Work with contractor personnel to provide information and research for QDRs. Distribute TIRs and QDRs to appropriate personnel (Huntsville and Fort Rucker). Track all TIRs, QDRs, and QDR responses for the LTF aircraft. Maintain information in spreadsheet format for reference purposes. Track TBOs for all LTF aircraft. Maintain information in spreadsheet format for reference purposes. Clarify data collection questions and processes for other LTF members. Act as liaison between LTF group and RAM data section. Represent LTF in quarterly Failure Review Boards (FRB). Answer questions and concerns from other FRB members. Assist in final data scoring. Maintain an Aircraft Usage schedule for all LTF aircraft. Serve as back-up on off-site LTF deployments for transfer of digital and logbook data.

COBRO Programmer: Perform routine data processing reduction for aircrafts using a DOS batch program and ADAPS disks (for C-MIGITS), and DataMARS disks (for DataMARS). Verify collected data and minimize data loss. Troubleshoot and prevent data loss (hardware, software, personnel). Create dynamic charts and reports from the aircraft flights. Track data loss by percentage over time per aircraft. Track C-MIGITS and DataMARS disks for inventory. Create other reports and charts as needed. Develop, maintain and administer Microsoft Access database for flight profile cards. Create reports from the collected data and database (Oracle and MS Access). Maintains inventory for flight cards (C-MIGITS and DataMARS).

Troubleshoot RAM Collector errors with flight profile cards. Query databases and check tables in Oracle and MS Access. Work with personnel in Huntsville and ATTC to determine errors and fix them. Download data from aircrafts to VMEP and then to the Ground Base Station. Review maintenance needs for the aircraft and notify proper personnel.

COBRO Data Collection Team: The UniRAM LTF Data Collectors are responsible for the timely and accurate input of all maintenance, operational, and availability data for the LTF aircraft. These responsibilities include parts and maintenance research, interfacing with the aircraft electronic logbook system and the Oracle-based Profile Card database. Data Collectors thoroughly check LTF UniRAM for quality control purposes. Representatives from the UniRAM Data Collection section coordinate and lead an FRB on a quarterly basis. The UniRAM Data Collection section submits a report consisting of an FRB Summary (FRB notes, action items, attendance rosters, and scoring results) following each FRB. TheUniRAM Data Collection section produces and submits UniRAM reports as required.

Huntsville LTF Members:

Westar Senior Engineer (Vacant): Serves as the chief engineer of the LTF Program. Provides technical expertise to the LTF PM and recommends technical innovation and growth. Provides leadership and professional growth to the LTF IPT. Coordinates analyses methodologies and results with appropriate personnel in ATTC, AED, IMMC, and program management leaders. Develops methodologies and technology to enable LTF to be the test best for the Army CBM effort. Supports the communications process described in the LTF business plan. Participates in internal and external LTF meetings.

Westar Flight Analysis Engineer: Design database queries to extract information to be exported to spreadsheet. Design Formulas to convert regime recognition data to component damage indices. Import flight regime information into spreadsheet. Monitor flight regime information for discrepancies. Report analysis of LTF data. Provide comparison information regarding LTF vs. design expectations of components. Investigate part failures using flight information, pilot feedback, flight substantiation reports, etc. Assist with the TSOF process.

Westar Senior Software Analyst: Provide software design and development to the LTF Program in support of the customer, as directed by the LTF data analysis Team Lead. Software design and development includes providing software solutions that meet the needs of the LTF program as defined by the LTF data analysis Team Lead. This includes finding the means by which the LTF program can better serve its customer through improved analysis and/or speed in data processing. Provide feedback to the customer concerning recommended areas for further analysis and methods for conducting additional analysis. Participate in the preparation of briefings and technical papers to inform other organizations about the accomplishments, findings, and recommendations of LTF. Status Reports identify significant

accomplishments for the month and any specific actions forecast for the upcoming month.

Westar Senior Logistics Engineer: Establish technical points of contact for each airframe, model, and component at AMCOM, Safety Center, PEO Aviation, OEMs, CCAD, IMMC, Logistics Support Activity (LOGSA) [Logistics Information Database (LIDB)], AMCOM Logistics, and AED. Access and analyze LTF and necessary Army databases. Establish resource requirements based on trend analysis based on usage data and mission profiles. Reduce rate of operation and sustainment costs by analyzing component reliability shortfalls. Research QDR data history for trend analysis and engineering disposition. Establish priority for analysis based on QDR data and current component failure rates. Analyze safety issues involving component failures and maintenance inspection issues. Research 2 and 3 level maintenance concepts for impact on readiness and sustainment requirements.

Westar Data Analyst: Review data produced from LTF aircraft faults and other sources. Quantify/qualify savings/avoidances identified from the LTF program. Produce charts/reports for distribution at multiple levels. Maintain the Metrics charts and information for G4. Follow the progress of LTF action items still in work (i.e., QDRs). Initiate writing and assembling TSOFs. Maintain copies of submitted TSOFs and coordinate their distribution.

Operations Research Center (ORCEN), United States Military Academy (USMA):

Principal Analyst: Independent research specialist to the LTF Program. Provide Systems Engineering approach to LTF Program. Full-time analyst dedicated to supporting LTF to provide statistical and analytical research to support the current LTF efforts. Conducted a through review of existing documentation and interviews of appropriate personnel to fully understand the current LTF mission and recommend changes. Determine the statistical significance of the current LTF data in relation to the rest of the Army fleet. (Identifying Metrics for this task). Determine the number of aircraft, flight hours, and duration required to statistically represent (with 90% C.I.) the entire fleet during Phase II. Determine the statistical significance of LTF data with 25 aircraft expansion during Phase II. Investigate the risks and uncertainties associated with 25 aircraft expansion during Phase II. Provide guidance and analysis to indicate the duration and/or number of iterations necessary for ATTC LTF aircraft to fly specified damaging flight regimes. Provide analysis of digital collection needs to determine the uncertainty associated with regime definition assumptions, and determine the cost/benefit for obtaining additional parameters.

Test & Integration Manager: Serves as the direct POC for LTF program at AED. Assists LTF with planning, coordinating and executing AED sponsored LTF testing at ATTC. Coordinates with the LTF senior engineer and APM LTF on technical issues and participates in LTF sponsored leadership and executive level meetings.

2.3 WORK FLOW WITH PRODUCTS AND APPROVERS

2.3.A HYPOTHESES TESTED BY PHASE (STUDY)

Study 1: Condition Based Maintenance (CBM) Hypotheses Testing by Phase

Mission: The LTF Analysis of CBM equips decision makers with information to change Army maintenance policy to a CBM program rather than the current time-based maintenance policy.

Definition: "On-Condition" or usage-based maintenance changes aircraft parts based on actual aircraft usage rather than aircraft flight hours.

Phase I: Establish Baseline

1. LTF determines what quality data to collect and why.
2. LTF determines how to test and implement an effective methodology to efficiently collect, transmit, store, and disseminate Reliability, Availability and Maintainability (RAM) data; OPTEMPO; flight regime data; flight profile data; and other DSC data from Army field aircraft.
3. LTF determines how to test and implement an effective methodology to efficiently produce QDRs, TIRs, and other field reporting procedures.
4. LTF determines how to test and implement an effective methodology to efficiently determine aircraft flight regimes flown.
5. LTF determines how to test and implement an effective methodology to efficiently determine on-CBM engineering methodology for correlation between aircraft usage and part fatigue and/or failure.
6. LTF determines how to test and implement an effective methodology to efficiently correlate the way the aircraft is flown to part damage.
7. LTF develops efficient methodology for implementation of Phase II, including transparent implementation for user, number of LTF personnel required, locations, reporting process, and aircraft digital collection sources.

Phase II: Validate Baseline

1. LTF develops efficient methodology for validation of Phase I process and methodology.
2. LTF determines what adjustments are needed to current engineering methodology for on-CBM.
3. LTF determines what adjustments are needed to normalize baseline data.
4. LTF determines improved DSC system capability for Phase III aircraft in order to effectively implement regime recognition.
5. LTF validates on-CBM by predicting part failures based on aircraft usage.
6. LTF determines how to implement an effective methodology to forecast maintenance parts based on aircraft usage.
7. LTF recommends Go/No Go to decision makers for Phase III implementation.

Phase III: Implementation and Steady State Operations

1. LTF develops efficient methodology for Phase III process and methodology.
2. LTF continues to monitor key metrics to fulfill stakeholder's objectives of reducing O&S Cost Drivers, improving readiness, improving safety through early hazard identification and risk mitigation, and improving resource requirements forecasting (parts, manpower, and money).

Study 2: LTF Hypotheses Testing: Health Usage Monitoring System (HUMS)

TBP

Study 3: LTF Hypotheses Testing: Aviation Logistics Life Cycle Management Analysis

Aviation Logistics Life Cycle Management Analysis and implementation performs maintenance in a well-structured environment focusing on TM accuracy, repair parts quality, tools, and MMHs expended. This analysis develops methodologies and procedures suitable to conduct fleet-wide logistics analysis.

Study 4: LTF Hypotheses Testing: Value Added Testing

TBP. Please see section 9.1 for definition of Value Added (VA) testing

2.4 ENGINEERING METHODOLOGIES – ALL PHASES

Phase I Methodologies

The data are obtained by non-volatile storage cards, which receive information regarding specific states of the aircraft from systems resident on the aircraft. There are two systems used in LTF: DataMARS & C-MIGITS.

DataMARS is used on:

- AH-64 A/D
- CH-47F

C-MIGITS is used on:

- UH-60 A/L
- CH-47D

DataMARS is placed on the aircraft, and obtains information directly from the 1553 MUXX bus of the aircraft, whereas C-MIGITS is a self-contained system which is placed on the aircraft. The information that is used by these systems is related to the time, position, and motion of the aircraft.

Examples of the Parameters monitored:

■ Time	■ Pitch Rate
■ Speed	■ Roll Rate
■ Pressure Altitude	■ Yaw Rate
■ Velocity (X, Y, Z)	■ Engine Torque
■ Heading	■ Acceleration (X, Y, Z)
■ GPS Longitude	■ Pitch Angle
■ GPS Latitude	■ Roll Angle

When the aircraft was designed, the various maneuvers and states that the aircraft would experience were developed. These maneuvers and states are categorized into flight regimes. Examples of regimes are 45° Left Banked Turns, Ground-Air-Ground Cycles (GAG Cycles), and Pullups@ 0.5Vh 2.5g. In some airframes, there are separate regimes depending on the gross weight (UH-60, CH-47). In others, regimes are differentiated into different deployment scenarios, which is a grouping of flight test configurations, to account for the different flight conditions experienced in training scenarios as well as in the Fleet [i.e. FHC (Field/High/Centerline) is composed of 85%LP1hi (Primary Mission Configuration, high altitude), 10%LP2 (Rocket Mission Configuration), 5% LP3 (Go To War Configuration)] (AH-64). The aircraft is expected to execute different regimes with varying frequencies, directly resulting in time ratios for each regime relative to its time flown. This forecast of regimes is called the flight usage spectra. This document provides detailed information regarding the fatigue experienced by aircraft due to different flight regimes. Different components of aircraft are sensitive stresses associated with certain regimes. The OEM performed cyclic stress tests that simulate the forces encountered during specific flight regimes for times that are defined are assumed to be the flight usage spectra of the deployment scenario. The fatigue experienced by the various regimes is then recorded. From this information, the fatigue life is extrapolated. In the case of the AH-64A/D, for each component, the deployment scenario that is used to determine the fatigue life is the scenario yielding the shortest life. In Phase I, these Fatigue Substantiation Reports (FSRs) are the foundation of the fatigue analysis used for computing the Relative Severity Of Usage (RSOU). The process for the RSOU is to obtain the relative damage of components resulting from flight usage of the aircraft. The damage accumulation is associated with time in specific flight regimes. From the time and the damage accumulation, a damage rate is formulated. In LTF, this damage rate is used in conjunction with flight regime recognition to show the RSOU which shows how much fatigue due to flight the component has experienced in comparison to how much fatigue the part should have experienced in during the same time period. This information shows the severity of the flight conditions that the aircraft is exposed to, in comparison to what the aircraft was designed to fly in.

Example Component FSR Data (100 hours)						
	Regimes:					
Regime	45	51	53	82	90	150
Time(Hour)	3.33	.05	1.33	1.411	.005	.030
Time % (100 hours)	3.33%	.05%	1.33%	1.411%	.005%	.030%
Damage	.0021	.0003	.0050	.0017	.0027	.0021
Damage Rate(/hr)	.000630	.006	.0038	.0012	.54	.07
Total Damage	.67563		Fatigue Life		148 Hours	

Example Flight Data						
Flight: 5 hours	**Regime:**					
Regime	45	51	53	82	90	150
Time(Hour)	0.2	0.042	0.13	0.000	0.23	0.004
Time % (5 hours)	12%	6.9%	21.5%	0%	40.0%	0.7%
Damage	.000126	.000252	.000494	0	.1242	.00028
Total Damage	.1561		Fatigue Life		32 hours	

Figure 2.4.1. Fatigue Accumulation example

Phase II Methodologies

Phase II will continue to address the transition from time-based maintenance to CBM. The manner in which maintenance is being performed currently does not take into consideration the conditions (i.e., environmental, severity of usage) the aircraft has been exposed to. Aircraft that are flown in combat and aircraft that are flown for training have scheduled maintenance performed after the same flight time, although they are flown under different circumstances, in different environments. Phase II will observe the environmental factors, as well as the severity of the usage of the craft to adjust maintenance times. This has begun in Phase I, as flights have been executed in various environmental conditions (i.e. tropical, desert, high altitude, and cold weather) to provide usage data under these conditions. This information will change the manner in which logistics is performed. The resulting system will take into consideration the environment the aircraft will be operated in, creating a scenario where part demand will be based on the requirements of the theater, rather than the current process, in which the demand history is the basis for future supply. This leads to an insufficient supply in the case of a shift from peace time to war time, which generally changes the physical location of the fleet, as well as the nature of the usage of the aircraft, and subsequently the attainable life of the components. Another step that will improve the fidelity of the data obtained through the LTF program is improving the correlation between fleet usage and test flights performed at ATTC. In Phase II of the program, fleet aircraft will be equipped with the same DSCs used on test aircraft at ATTC. This will allow for a direct comparison of the data that are obtained by aircraft in the fleet with aircraft used at ATTC. Currently, we use data from the fleet, and attempt to duplicate it at ATTC. With instrumented fleet aircraft, we can observe any discrepancies between what is perceived to be fleet usage and actual fleet usage, and how these flights are observed by the DSCs. The resulting shift will address the concern that flight regime recognition is a factor of the condition of a component, and other aspects involved in flight must be taken into consideration to make CBM a reality. Regarding the original FSR data, the process that the OEM used for fatigue life was not performed in flight, and as a result, components generally

are not retired in the vicinity of their OEM fatigue life. The regime recognition process could show correlations between flight and resulting conditions of components. Further, with aircraft in the field, we can observe the degradation that occurs to fielded aircraft components in various environments, and use that information that shows effects of environment, showing the reaction to increased altitude, heat, humidity, and other factors. What is currently being used by LTF is sufficient in the context of its use: as a proof to the claim that the flight regimes that the aircraft are claimed to be exposed to according to OEM data is not indicative of fleet usage. The next logical step is to further refine the system to address CBM requirements. Fleet data will offer real-world data regarding flight. All flight data that are obtained will be placed inside of a database for trend analysis. Phase II will see the infrastructure for data collection, sharing, processing, and storing finalized. The aircraft used in Phase II will not be in a controlled environment, as aircraft currently are at ATTC. This circumstance will bring a necessity to develop methods to bring the data to a central point for processing, sharing, and storing.

Phase III Methodologies:
This will be the point that aircraft in the entire fleet will be instrumented with DSCs to transition completely to CBM. This will be the point that the system for maintenance, supply, and logistics will shift for the aircraft we have been using in LTF. This phase will address the shortcomings of current phase maintenance, component supply in various environments, and reduce unscheduled maintenance due to excessive usage.

2.5 VALIDATION SYSTEMS

1. Document metrics utilized in gathering data on airframes, components, flight regimes, environmental factors, and frequency of occurrence.
2. Determine information needs and support requirements form AED.
3. Detail uncertainties of present engineering methodologies. Outline further requirements for more complete, concise data gathering methods.
4. Document accuracy used to determine the frequency and duration of damaging flight regimes.
5. Establish flight baseline for flight regimes, OEM FSRs.
6. Validate and baseline conclusions from OEM TBO hours, methodologies used. There are clear and substantial differences between what the OEMs conclude and other agencies (i.e., AED) conclude. Ensure that the same types of methodologies and requirements are utilized in each case of component TBO and MTBF.
7. Use sensitivity analysis to determine and challenge assumptions derived from other analyses.
8. Compare the results of engineering analysis completed by LTF program with similar programs that are available. These programs may involve aviation, armor, and vehicle. Similar collection and analyses are used on numerous programs for like results.
9. Identify high risk and high return areas for immediate impact of LTF analysis.
10. Ensure that LTF flight parameters are similar to flight maneuvers performed by operational units.
11. Increase data gathering ports and uniformity of methods used. Not only electronic data gathering, but use of methodologies and systems for mechanical, structural, propulsion, and rotary measuring instrumentation. These methods involve detection within design parameters of any abnormal behavior for any component or system that displays a trend of under performance.

12. Use gathered data to identify problem areas and/or components earlier in their life cycle. Use of data and established fault trends may impact materials used or redesign of components. This effort may reduce maintenance requirements, either scheduled or unscheduled, for systems, components in the future.

2.6 DATABASE INTERACTIONS

Currently, the LTF program interacts with two databases that are under its direct control. This is in addition to the numerous other databases that LTF can access indirectly to collect supporting information for its findings. Since the interface with the other databases requires human interaction with personnel outside the LTF program to transfer or search for the information, this section will focus primarily upon the regime recognition process for a flight, and the path that the data travel from aircraft to each of the dedicated servers.

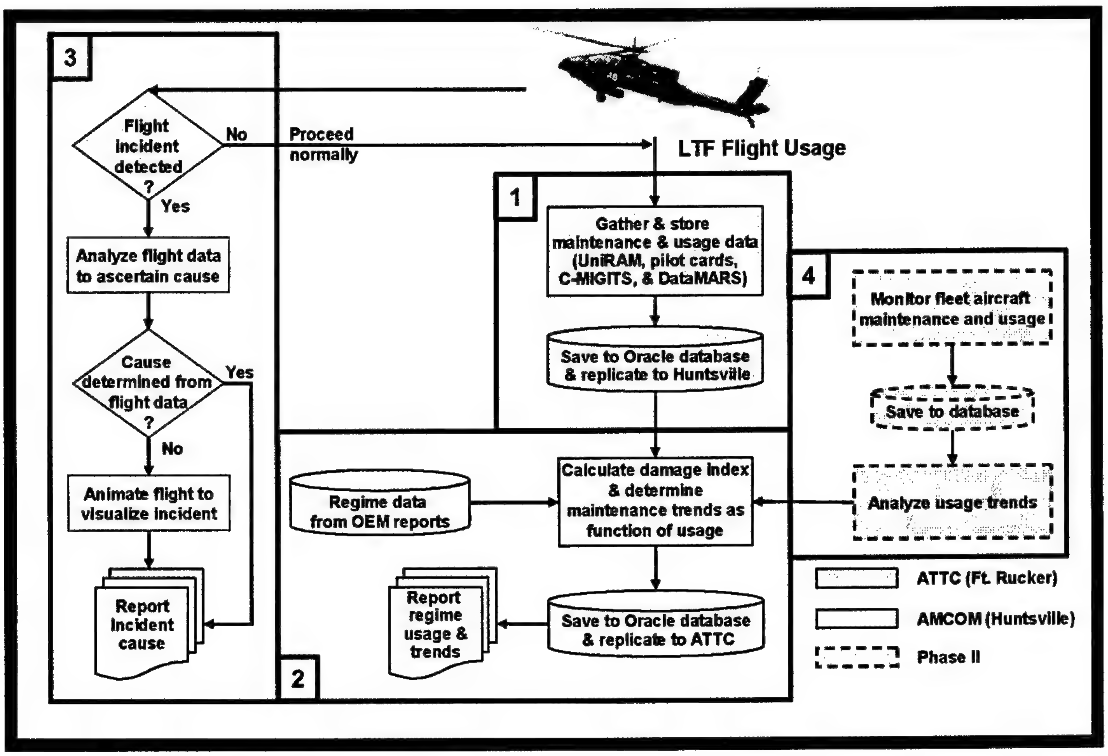


Figure 2.6.1 Lead the Fleet Data Analysis Process

LTF Portal allows AED, LTF Team, G4, Aircraft PMs and all other users of LTF data to communicate, share data and work in a common area. Each time information is requested or analyzed, the LTF Team generates a report; if the report was generated from data currently stored only in UniRAM then a dynamic version is built by the LTF data analysis team and made available via the Portal. In Phase II, LTF will need to develop reports from sources other than UniRAM (ICS's VMEP, ULLS-A, etc.), which would greatly increase the usefulness of the Portal. Furthermore, investigation and testing will occur to determine how much data from other sources should be preserved locally at the LTF enterprise database. As more intelligence is built into the dynamic reports, it will be possible to automate some high

order analysis of the data. Once the automatic analysis of the data is validated, it will be possible to perform reactions to the data automatically. Examples of reactions to data that could be targeted for automation are pilot scheduling, aircraft maintenance scheduling, updating aircraft manuals, ordering parts, and LTF flight regimes changes.

LTF recognizes the need for an enterprise level database that consolidates information from multiple heterogeneous databases and acts as a central communication point for the dissemination of Army fleet issues. The database also needs to provide intelligent analysis tools for Engineers, AED, Aircraft PMs, and Army G4. During Phase I, LTF has utilized the UniRAM database as central storage for all RAM, Pilot Profile Card, and Aircraft State data. The LTF Portal is a dynamic web site that tailors itself to each user based on permissions and preferences.

2.6.1. Regime Recognition

The regime recognition process originally consisted of a series of Excel spreadsheets that used state data and bounds, checking to determine flight regimes on a sample-by-sample basis (sample consisting of one time slice of all parameters available to each of the data recording instruments). The decision was made to migrate this process from an Excel spreadsheet to a more automated process. The benefits were great to the LTF program in that what used to be a time intensive process (two man-hours per flight hour processed) was condensed into a much less human intensive process. Currently, the average time for a flight to process is around five minutes per flight hour. More importantly, the automated process removes the chance for human-induced errors in the regime recognition process.

Regime Recognition Program
The regime recognition program was designed to be entirely autonomous. Written in C++ for the Windows platform it was designed to be run as a service on a standard Windows server. This allows speed, compactness, and near human free interaction.

Process of LTF data (Regime Recognition Program)
Data located on the Huntsville Oracle server [in Binary Large Object (BLOB) format] is read into the program using the Oracle call interface. LTF data are parsed out into vector-based storage mechanisms inside the program on a time-based index. This allows for the implementation of a threaded solution at a later date. Depending on the airframe and the data storage mechanism, the data for given parameters may need to be smoothed on a time-based averaging algorithm. This cleans up any noise inherent in the system. This is done on a single pass implantation for each parameter that is to be smoothed. During this first pass on the data, continuity checks are performed, as well as data merging for some parameters based on the data collection system, namely, the DataMARS system on the AH-64D. There is currently a problem with the DataMARS system on the AH-64D in that there are data dropouts in specific spots of the data bus at random intervals. While there may not be data at one location, the data will be always at another. To get around the problem of discontinuity, data must be captured from more than one location on the bus and stored in the files for assimilation by the program into one consistent, coherent stream of data for the regime recognition program. This is just an example of data manipulation that the automated process must perform to ensure consistent results.

Once the data smoothing and consistency checking is complete, the program enters into the bounds checking for the regime detection. For each group of possible regimes, the program will check the pertinent state data and determine whether, for a given time slice of data, the aircraft was actually in a given regime group. Based on that data, the regime is further broken down into actual regime instead of just the overall group. Given that an aircraft may be in multiple regimes at a given time, the program stores on a time basis, every regime the aircraft is in as it progresses through the flight. This is used in the next step of the regime recognition process when the regimes are rated in terms of most damaging and given a priority of damage accrual.

For each aircraft there is a priority list which each time slice of regime data is ranked against. Some regimes are more intensive than others and are mutually exclusive. For those mutually exclusive regimes (as defined by the OEM), the regime with the higher damage inducing potential is chosen above the smaller, less intense regimes. There are some regimes that are not mutually exclusive, and as such, they are not filtered out in the final tally of the regime count. At present, the regime recognition program does not store in the database the actual time-based regime data. Only the total number of times (per time slice, 5hz for DataMARS and 4Hz for C-MIGITS) is stored in the database for retrieval.

Future implementations
In the future, LTF will integrate the OEM damage calculations into the program for storage to the database. Currently, damage is calculated using an Excel spreadsheet. Using the regime recognition program will help in visual productions for estimations through the portal. This will provide means to graphs usage intensity versus any number of variables, including environment, altitude, loads, etc.

As LTF moves toward Phase II and begins to work toward a solution for implementing CBM, several changes will have to be made to reduce the human component of data interaction and migration. LTF realizes that the more transparent its implementation of a CBM system is, the more likely it is to be adopted by general Army Aviation.

Phase II of LTF will need to concentrate upon data flow between existing Army logistics and maintenance databases. The current plan is for LTF to be a central repository for the dissemination of analyzed data. This data can come from any number of sources including its own gathered data. Without a standardized interface between the LTF application server and the myriad of other databases that house information pertinent to the final analyzed information, the LTF program will be forever dependent upon human interfaces to produce a finished analysis. To move to CBM, the LTF program realizes that until human interaction, as well as the possibility for error it introduces, is removed, the overhead for maintaining records that support the CBM initiative will be too great to be cost-effective. Unhindered access to all pertinent information will allow the LTF program to generate automated reports that can assist the Warfighters and money holders in decision making.

In addition to information sharing, the LTF program will concentrate upon finding the best solution for the transfer of large amounts of data from remote places. A systematic hierarchy of preferred data transfer methods will be created and tested using the additional locations added by Phase II. Some of the methods of data transfer that will be researched are Satellite,

Broadband, Secure FTP, and Physical Media through military supply lines. Planning will occur which allows for the mobilization of the unit. Methods of transferring data while the unit is mobilized will be limited and dynamic. Subsets of the data will be created and pass back via bandwidth limited methods to get the data back faster. Meanwhile a portable backup will be kept with the unit incase re-transmission is necessary. Backup data will only be kept until the unit receives confirmation the data successfully transferred back to the repository. If the backup medium fills up then the oldest data will be removed first but this event should only happen in the most dynamic and hostile environments.

2.6.2. DATA CODING PROCESS

The FRB meets on a quarterly basis. The following representatives attend the FRB:

- ATTC
- Training and Doctrine Command (TRADOC) Engineering [in support of the Directorate of Combat Developments (DCD)]
- AMRDEC Reliability, Availability, and Maintainability (AMRDEC RAM)
- PM's Office
- AED

These members meet to identify failure trends and maintain consistency in the scoring of aircraft maintenance data.

The board members review every unscheduled maintenance action for each of the LTF aircraft. The primary emphasis for this review is the scoring of unscheduled maintenance actions.

A different Failure Definition Scoring Criteria (FDSC) mandates the scoring for each airframe. The U.S. Army TRADOC Combat Developments Engineering Division has defined these scoring methodologies. Members of the different agencies use the scoring criteria to score LTF data and Sample Data Collection (SDC) data from fielded units. The scoring allows users to quickly determine how many mission aborts, system failures, and maintenance errors are occurring on each airframe. The UniRAM allows further analysis through use of Work Unit Codes (WUC) derived from the airframe Functional Group Codes (FGC). These codes allow ease of data queries for system failures, Mission Affecting Failures (MAF), and Essential Maintenance Actions (EMA) sorted by airframe FGC (to know which system in the aircraft failed or caused the abort). Conceivably, one could run a query to return the number of aborts caused by a specific FGC having a status of (X) within a specific timeframe. There are over 25 data elements in the UniRAM maintenance database usable individually or in numerous combinations to sort the maintenance data.

While the FDSC defines the scoring, individual interpretation still applies when scoring data. The LTF data collection effort serves as a sort of control group for the scored data. The LTF data are the only data reviewed by a combination of agencies in order to create consistency in the scoring. The FRB members reach a consensus for each scoring element on every LTF aircraft.

Scoring Basics (for AH-64 aircraft)

Block 1 = Potential (maintenance) Termination
Block 2 = Failure Classification (independent hardware failure, dependent failure, operator induced, etc.)
Block 3 = Maintenance Task Time Chargeability
Block 4 = Source of Equipment (contractor furnished, government furnished)
Block 5 = Mission Failure Classification (safety failure, system failure, mission failure, etc.)
Block 6 = Data Management Subsystem Detection
Block 7 = Data Management Subsystem Isolation
Block 8 = Mission Essential Function (example: flyability only or navigation only, etc.)
Block 9 = Affected Missions (example: all missions, all day missions, etc.)

MAINTENANCE REPORT

(Report filename: MNT)

Page 1 of 4 **Report Date: 28-JAN-04** 04028

Test Phase: LTFA64 **EI Sn:** 9100120 **EI Id** L20

Mission Design Series

Control Number 03266L20023M **Ref CN** 03266L200210

End Item Information

Event Beginning Date & Time	EI Age	Initial Delay	Event Ending Date & Time	EI Age	Test Age	Status EI Ar EI Ot	Loc	Man Hours Direct	Man Hours Indirect	Hrs ACM Direct	Hrs ACM Total
03266 1444	1434.3		03304 0823	1442.3	694.8	2	OZR	8.50	0.00		

Functional Group Code — **Maintenance Subject Component**

WUC 10M	FUEL TRANSFER VALVE	
Part No 736300-9	SHUTOFF VALVE,FUEL TRANSFER	
Part Sn 045943-0898		Pos 30

Failure Definition / Scoring Criteria

											Result	Sc No
Preliminary	3	D	5							R		
	1	2	3	4	5	6	7	8	9	0	1	
Final	N	C	C	C	3	N	N	A	N		Y	6

Image Ct: 0
EI Op: A
Spec_no:
Spec_sc: 1 2

Maintenance Dynamic Component (If Applicable) Scoring

WUC | Part No | Fault (Discrepancy) Status — Part Sn | Pos

Maintenance Information

Func	J	REPAIR — Maintenance Function
Intrvl	G	UNSCHEDULED
Level	O	AVUM/ORGANIZATIONAL
Directive No		TIR #KF-A000044 & 45

Mal Eff — **Malfunction Information**

Mal Eff			
Sys 3	How Rec	G	VISUAL — How Recognized
Opn	When Dis	V	POST FLIGHT INSPECTION
Msn	When Occ	Q	SERVICING
	Fail Code	381	LEAKING (LIQUID)

NARRATIVE

LOGBOOK ENTRY- (23 SEPT 03) (CIRCLE RED X) AFT TANK VENTS FUEL WHEN PRESSURE REFUELING. ACFT RESTRICTED TO GRAVITY REFUELING AFT TANK. Deficiency Description

ACTION TAKEN- REPLACED THE PRESSURE RELIEF VALVE AND THE SHUTOFF VALVE. Deficiency Corrective Action

NOTES:
1. A TEST INCIDENT REPORT (TIR) HAS BEEN WRITTEN ON THE AFT FUEL TANK PRESSURE RELIEF VALVE AND ASSIGNED NUMBER KF-A000044.
2. A CATEGORY II PRODUCT QUALITY DEFICIENCY REPORT (PQDR) HAS BEEN INITIATED, FOR STATISTICAL PURPOSES ONLY, ON THE AFT FUEL TANK PRESSURE RELIEF VALVE AND ASSIGNED CONTROL NUMBER W91B28030125.
3. A MEMORANDUM WAS RECEIVED FROM AMCOM STATING THAT PQDR NUMBER W91B28030125 HAS BEEN ASSIGNED AMCOM CASE NUMBER M23H70704 FOR THE AFT FUEL TANK PRESSURE RELIEF VALVE. THE SUBJECT PQDR WAS FORWARDED TO AMCOM, FOR STATISTICAL PURPOSES ONLY. THIS INFORMATION HAS BEEN INCORPORATED INTO THE EDRS DATABASE FOR FUTURE TREND ANALYSIS, AND ALSO STATED THAT "THIS LETTER CONSTITUTES CLOSING ACTION".
4. A TEST INCIDENT REPORT (TIR) HAS BEEN WRITTEN ON THE FUEL TRANSFER SHUT-OFF VALVE AND ASSIGNED NUMBER KF-A000045.
5. A CATEGORY II PRODUCT QUALITY DEFICIENCY REPORT (PQDR) HAS BEEN INITIATED, FOR STATISTICAL PURPOSES ONLY, ON THE FUEL TRANSFER SHUT-OFF VALVE AND ASSIGNED CONTROL NUMBER W91B28030126.
6. A MEMORANDUM WAS RECEIVED FROM AMCOM STATING THAT PQDR NUMBER W91B28030126 HAS BEEN ASSIGNED AMCOM CASE NUMBER M23H70705 FOR THE FUEL TRANSFER SHUT-OFF VALVE. THE SUBJECT PQDR WAS FORWARDED TO AMCOM, FOR STATISTICAL PURPOSES ONLY. THIS INFORMATION HAS BEEN INCORPORATED INTO THE EDRS DATABASE FOR FUTURE TREND ANALYSIS AND ALSO STATED THAT "THIS LETTER CONSTITUTES CLOSING ACTION".

Figure 2.6.2.1. Sample Maintenance Report

3.0 PRODUCTS AND DELIVERABLES

3.1 DEFINITION OF EACH PRODUCT FROM EACH ACTIVITY BLOCK – TSOF, READINESS DASHBOARD, FORECASTING, RCM

The Army LTF Program produces tangible products to the U.S. Army. The ultimate stakeholders in LTF are the Warfighters in the operational environment. Therefore, LTF products enable a reduction in O&S costs, enhancement of safety, and an increase in operational readiness in the field. LTF ensures incorporation of detailed Cost Benefit Analysis (CBA) throughout the process, as well as timely presentation of products and deliverables. In addition, LTF collaborates with other Army and Department of Defense (DoD) agencies to implement changes that resulted from findings, analysis, and recommendations in LTF products.

CBA

LTF CBA estimates and totals the equivalent value of the benefits and costs of the LTF findings and recommendations to establish whether they are worthwhile to the Army. LTF CBA will include the following principles:

- Common units of measurement: LTF CBA utilizes common units of measurement for costs and benefits (i.e., U.S. Dollar, Hour, and Percent).

- Valuation of costs and benefits in relevant operational terms: LTF CBA includes cost and benefit values that are recognized and relevant to the operators in the field [i.e., MMH and Maintenance Flight Time (MFT)]. Including these common terms in CBA, LTF is able to compare and analyze cost and benefit values against the large Army database. This process allows LTF to calculate objective CBA results with a high level of confidence to the Army leadership. Ultimately, these costs and benefits will lead to positive impacts to O&S costs, safety, and operational readiness.

- Evaluation of the intangible benefits: LTF CBA incorporates intangible benefits that produce positive impact to overall Combat Effectiveness. An example of an intangible benefit is the increased safety of aircraft reliability in its dynamic components.

- Identification and emphasis on the LTF impact to overall Army benefits: LTF CBA articulates the importance of LTF impacts and its positive benefits to the Army.

- Unbiased validation of LTF CBA: An external unbiased agency, ORCEN, USMA, validates the LTF CBA.

Findings and Reports: LTF provides formal collaboration means to articulate LTF findings, analyses, and recommendations to other Army agencies. These will include succinct and relevant materials that will assist collaborating members to quickly implement actions to positively affect readiness in the field in a CBM environment. LTF generates appropriate products (findings and reports) throughout the life cycle of the LTF process. In addition,

contents of the product will vary depending on urgency of the requirement and maturity of the LTF process. The following items may be included in the findings and reports:

- Background
- Summary
- Research results
- Supporting documents and data
- Correspondence
- Historical data
- CBA
- Recommendations

The continuous assurance table (Table 3.1.1) depicts possible products that could be generated to communicate between collaborative members.

Table 3.1.1 Continuous Assurance Table

Steps	Products
Verification	Verification Report
Configuration Management	Items Controlled, Change Approval, Baseline Definitions
Validation	Validation Report, M&S Certification Recommendation
Technical Review	Concurrence to Proceed, Actions to be Completed, Appropriate Algorithms/Outcomes
Project Management	Work Breakdown Structure, Work Definitions and Deliverables, Schedule, Milestones, Risk Management Plan, Project Status

<u>Readiness Dashboard:</u> Available via the LTF Portal, the Readiness Dashboard is a collaborative database that will provide real-time LTF updates to Army leadership. These will include interactive programmatic and analytical LTF information that will provide a common operating picture of Army Aviation sustainment.

<u>Technical Summary of Finding (TSOF)</u>: Currently, LTF reports findings to Army agencies through TSOF. LTF created TSOF in order to quickly inform the key Army decision makers the impact of LTF findings and procedures to implement changes. In addition to TSOF, LTF reports findings through the normal Army test, maintenance, logistics, and programmatic reporting systems. The following is the outline for TSOF.

1. *Executive Summary
    a. Problem Statement
    b. Discussion
    c. Conclusion
    d. Recommendation

2. *Aircraft Discrepancy
    a. Electronic Logbook Entry
    b. UNIRAM Data

3. PQDR Submitted/TIR Submitted

4. PQDR Response

5. PQDR Historical Data-All PQDR available for aircraft part, including response

6. DA Form 2028 Recommended Changes to Publications and Blank Forms
    a. Technical Drawings
    b. Photographs

7. DA Form 2028 response to Recommended Changes to Publications and Blank Forms

8. Extracts from TMs as required to clarify the issue.

9. Correspondence with Technical Points of Contacts

10. Critical LTF Aircraft Flight Data – Regime Recognition for relevant period of time

11. Critical OEM Regime Data

12. DSC Data for relevant period of time (if available)

13. *Cost/Benefit Analysis

*required items

3.2 DELIVERABLES –QDRS, TIRS, REPORTS

PQDRs
PQDRs are submitted for the following reasons:

- To suggest corrections and improvements to aircraft and aviation-associated equipment, including mission-related equipment.
- To alert the Army to problems encountered by the user due to receipt of defective equipment.

The PQDR data are used by National Maintenance Point, logistic, and other managers at AMCOM to perform the following tasks:

- To assess the fault, failure, or condition of the item.

- To validate or change the current maintenance and/or inspection standards to maintain airworthiness and improve the operational readiness of aviation equipment per AR 750-1.

LTF will submit a PQDR for the following conditions:

- A materiel failure or fault that would cause a hazard to personnel or equipment, or safe completion of the mission.

- The equipment does not work properly because of bad design and/or materiel, or low-quality workmanship during manufacture, modification, conversion, repair, overhaul, or rebuild.

- When environmental conditions cause aircraft; aviation associated equipment, including mission related equipment; components and modules; repair parts; systems; and/or subsystems to fail.

- Stock Funded Depot Level Reparable (SFDLR) items are found, during initial test or use, to be defective and such defect is not caused by user accident, misuse, improper installation and/or operation, unauthorized repair, or alteration.

The two categories of PQDRs are as follows:

1. Category I PQDRs are:

    a. used to describe an unsafe condition, operational or maintenance procedure for aircraft, mission related equipment, component and module, or repair part whose use is critical to airworthiness, and any failure that could be expected to cause loss of the aircraft and/or serious injuries to the air crew or ground personnel.

    b. used when the reason for failure, identified or suspected, does not provide enough warning for the air crew to complete a safe landing, and it is reasonable to assume that the problem could be present in other aircraft of the same MDS.

    c. used to report incorrect or missing data in technical publications that may cause a hazardous operational or maintenance problem. Technical publication errors are reported with DA Form 2028.

    d. prepared and sent immediately upon discovery of any condition involving personnel safety or Safety of Flight (SOF) as defined in AR 95-1.

2. Category II PQDRs are:

   a. Submitted for items that do not meet the definition of a Category I item.

   b. Submitted for items that may adversely affect serviceability, durability, maintainability and/or reliability of an aircraft system, subsystem, repair part, component and module, and/or mission related equipment.

TIRs

TIRs are prepared to provide the results of any incident occurring during LTF testing and serve as interim reports. TIRs are prepared in accordance with AR 73-1 and Department of the Army Pamphlet (DA Pam) 73-1. A PQDR submission automatically requires a TIR.

TIRs are classified as Critical, Major, Minor, or Information. Critical and Major TIRs require production of corrective action data; others are reviewed for possible corrective action. The TIRs are posted for inquiry and analyses on the Visual Data Library System (VDLS).

DA Form 2028

DA Form 2028, Recommended Changes to Publications and Blank Forms, is prepared to suggest changes to TMs, Regulations, and Publications.

4.0 COMMUNICATIONS PLAN

4.1 CRITICAL COMMUNICATIONS NETWORK

4.2 PERIODIC MEETINGS WITH PROPOSED AGENDAS

4.3 UPDATES TO PMS AND OTHER STAKEHOLDERS

4.4 SAFETY CENTER UPDATES TO THE CSA

4.5 INCIDENT REPORTING (SIR CRITERIA)

4.6 STANDARD BRIEFINGS

4.7 KNOWLEDGE SHARING

5.0 METRICS AND REPORTING

LTF is a program designed to identify and solve critical issues with component reliability and sustainment in the aviation fleet before such issues manifest themselves in the operational fleet and degrade readiness in a theater of war. The LTF program is expected to save the Army time, money, resources and reduce risk. LTF resources currently consist of six aircraft stationed at Ft. Rucker, AL. LTF developed the following Metric charts to measure effectiveness: Readiness, Operations & Support (O&S), Safety, and PQDRs. These charts represent the Metrics that were directed by HQDA, and the Army Audit Agency (AAA) initiated an audit of the LTF Metrics on 7 April 2004.

Each category Metric was quantified in a manner that could be easily replicated during inspection. All Metrics, with the exception of Readiness, were quantified in dollars. Appropriate Army or DoD databases or publications were used to determine the dollar value of LTF submissions. Examples of these databases are the OSMIS, DA Form 2410 (Record of Component Repair/Removal) and the Electronic Deficiency Reporting System (EDRS). In instances where there was no listed source for the information needed, the data that was experienced at the ATTC was used and cited in the Cost/Benefit analysis for that submission. The data used from ATTC is stored in the ELAS and UniRAM databases maintained by ATTC and LTF. Standard information is also used from TB 43-0002-3, Maintenance Expenditure Limits for Army Aircraft, and DoD military composite pay and reimbursement rates. The measure for Readiness remains in hours. While Maintenance Man-Hours and Maintenance Test Flights (MTFs) could be configured to be shown in dollars, hours of availability for aircraft could not.

5.1. TYPE DEFINITIONS

The four metrics reported by LTF are: Readiness, O&S, Safety, and PQDR.

Readiness
Readiness is the measurement of a units' ability to operate its aircraft. It is measured in a percentage with goals established by AR 700-138. The percentage is computed by dividing the hours an aircraft is available in a month by the total hours in that month. The Fully Mission Capable (FMC) goal for the UH-60 is 75%, while the FMC goal for the AH-64 and CH-47 is 70%. These goals are directed by the DA and are contained in AR 700-138. Commanders must report their units' Readiness rate monthly. LTF will assist the Army in achieving these Readiness goals by identifying areas where aircraft downtime can be reduced. Examples of improvement areas are to identify and eliminate defective parts before they reach units in the field; identify, test, and submit new tools that decrease maintenance times; and introduce new maintenance procedures that decrease maintenance times. LTF will enhance Readiness by forecasting the type and amount of parts needed when units deploy by advance testing in adverse environmental locations.

For example, Figure 5.1.1 represents three contributions to Readiness that have been submitted by LTF. The Pitch Change (PC) Link Bearing is a one time event while the Engine Nozzle Modification and the Special Tool are each annual enhancements. A brief calculation explanation immediately follows the figure.

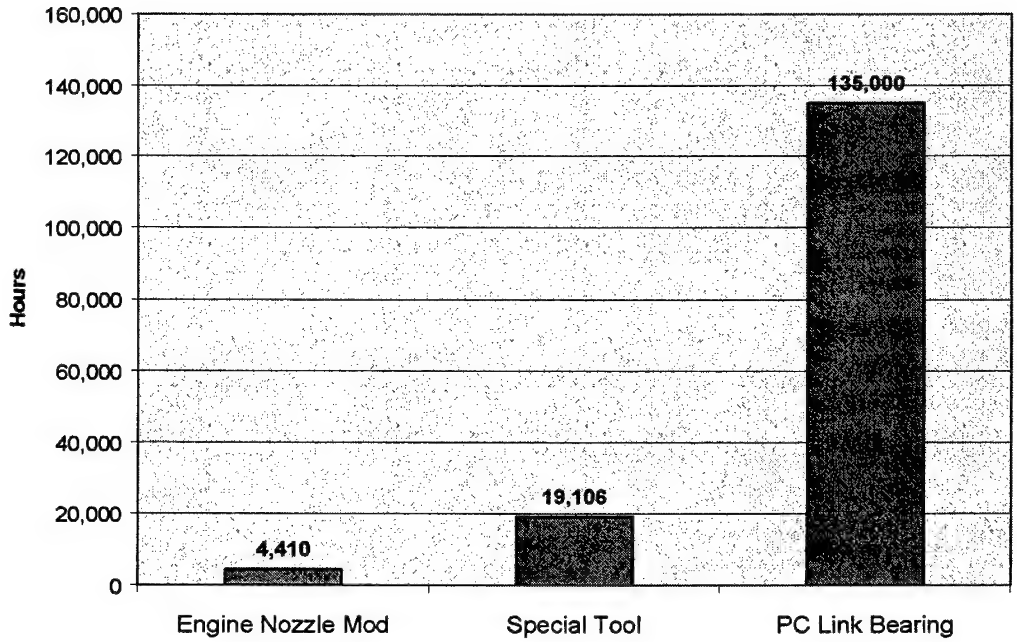


Figure 5.1.1 Readiness Metric

Engine Nozzle Repair Modification. Time was calculated using maintenance time data from the DynCorp Engineering Standard multiplied by the average number of occurrences according to OSMIS. 14 x 315 = 4,410

CH-47 Drive Bearing Tool. Normal annual down time = 40,224 hours
(419 maintenance Events X 96 hours down time per event) (OSMIS, ATTC maintenance records)
New annual down time = 21,118 hours
(419 events X 2.1days / event X 24 hours / day) (OSMIS, ATTC maintenance records)
40,224 - 21,118 = 19,106

PCL Bearing. Time was calculated using the down time experienced at Ft. Rucker x half the # of discrepant bearings (assumed 2 bad per aircraft). 135 * 1,000 = 135,000

O&S

O&S costs are a huge portion of the Army Aviation budget. Reducing system ownership costs directly contributes to the Army meeting its modernization objectives. The cost of system ownership includes costs associated with operating, modifying, maintaining, supplying, and disposing of weapon/materiel systems. Increasing emphasis is being placed on reducing O&S costs. LTF can help reduce the increase in the Army's O&S costs in two primary areas – MTFs and MMH. LTF will impact both areas by identifying substandard

parts, reducing the number of repairs that require MTFs, and introducing tools and procedures that minimize MMHs per repair.

For example, Figure 5.1.2 represents three contributions to O&S that have been submitted by LTF. The Pitch Change (PC) Link Bearing is a one time event while the Engine Nozzle Modification and the Special Tool are each annual enhancements. A brief calculation explanation immediately follows the figure.

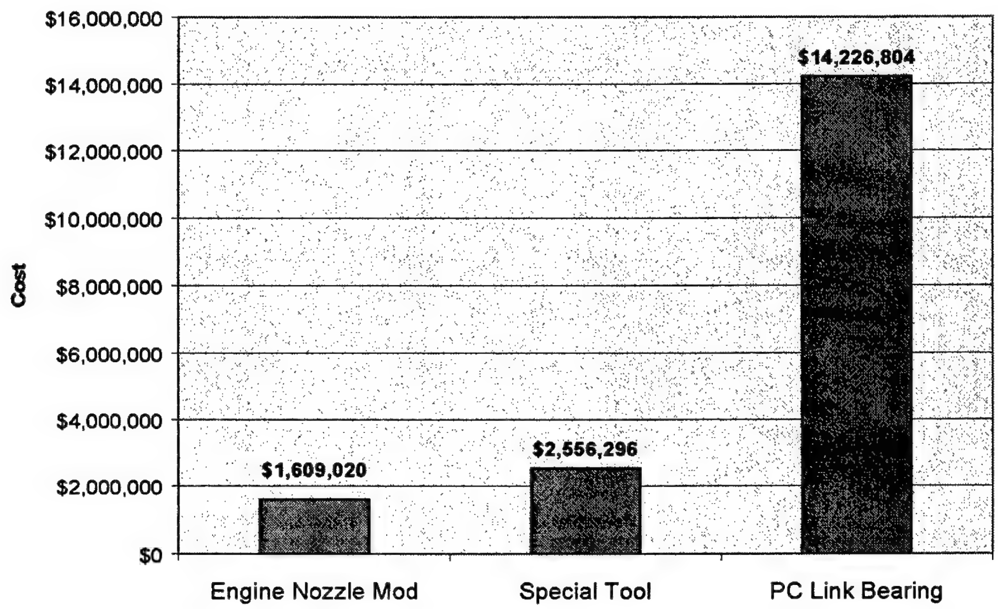


Figure 5.1.2 O&S Metric

AH-64 Engine Nozzle Repair Modification.
315 Replacements a year – OSMIS data from 2000-2002
Cut from a 16-hour repair down to a 2-hour repair @ $32 per hour (315*14 * $32= **$141,120**) - DynCorp Engineering Standard
No test flight (315 * $4,660 hr) = **$1,467,900** - DoD reimbursable flying hour rates and DoD military pay reimbursable rates
$1,467,900 + $141,120 = $1,609,020

CH-47 Special Tool. Normal annual maintenance cost = $816,044 (OSMIS, ATTC maintenance records, DoD military pay reimbursable rates)
Normal annual cost for MTF time = $1,942,903 – (OSMIS, DoD Reimbursable Flying Hour rates)
New annual maintenance cost = $202,651 = (OSMIS, ATTC maintenance records DoD military pay reimbursable rates)
$2,556,296 **Note*** This tool also saves 9 man-years of labor each year.

AH-64 PC Link Bearing.

Maintenance Man-Hour Cost: **(29.9 X $32.46 X 1,000) = $970,554** (ATTC maintenance records, DoD military pay reimbursable rates)

AH-64A Maintenance Test Flight Cost: (3 X $3,857 X 1,000 X 65%) = $7,521,150 (ATTC maintenance records, DoD Reimbursable Flying Hour rates)
AH-64D Maintenance Test Flight Cost = (3 X $5,462 X 1000 X 35%) = $5,735,100 (ATTC maintenance records, DoD Reimbursable Flying Hour rates)
Total = $14,226,804

Risk Management

Risk Management is the process of identifying and controlling hazards to protect the force. Risk is managed in a closed loop five step process. LTF contributes to identifying the hazards, assessing the hazards, developing controls, and then implementing the controls. For example, Figure 5.1.3 represents two contributions to Risk Management that have been submitted by LTF. Each column depicts the cost savings if one catastrophic event is prevented. A brief calculation explanation immediately follows the figure.

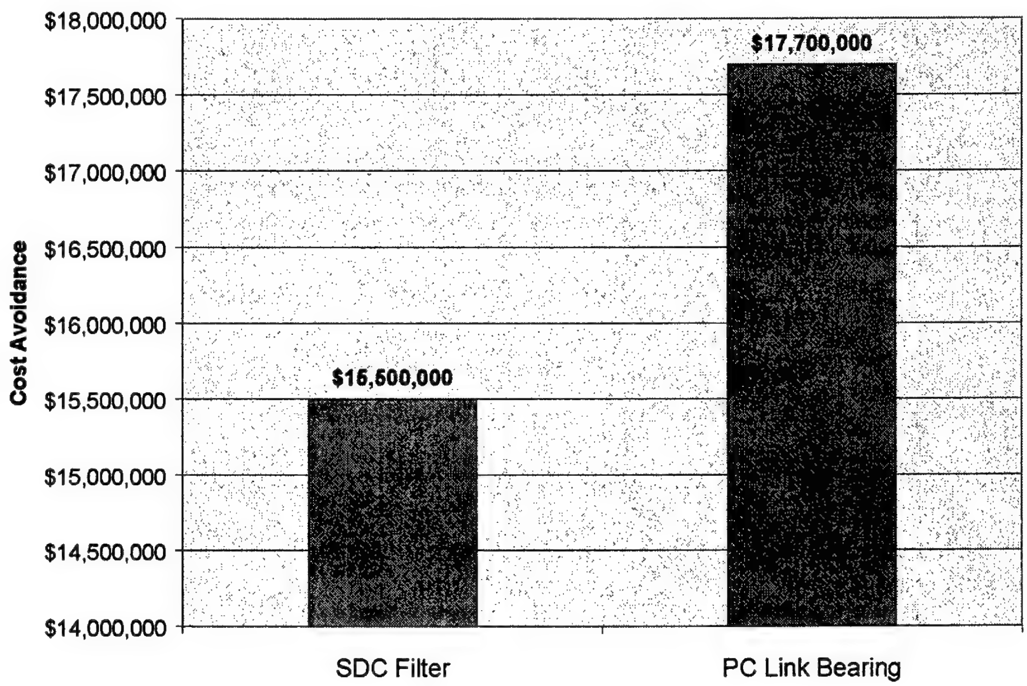


Figure 5.1.3 Risk Management Metric

AH-64 SDC Filter. The LTF team discovered a Shaft Driven Compressor filter had been sucked into the air intake after flight into rain. There is no caution or warning associated with flight into rain. The recommendations of the LTF team will be to insert a warning into the operators manual and redesign the filter so it will be more durable.

SDC data: Data was obtained from the following sources - TB 43-0002-3, Army Safety Center.

U.S. Army Safety Center reports two AH-64 lost due to SDC fires in the last three years. TB 43-0002-3 lists the replacement cost of one AH-64 as $15.5M. The cost of a crew was not included since an inquiry of the Army Safety Center showed no loss of aircraft crew due to an SDC fire.

AH-64 PCL Bearing:

Assumption: Given the rate of wear of the substandard bearings, the LTF assumed the potential loss of one AH-64 had the lot of 2,000 discrepant bearings been fielded and/or additional bearings been procured.

PCL Bearing data: Data was obtained from the following sources – TB 43-0002-3.

TB 43-0002-3 lists the replacement cost of one AH-64 as $15.5M. The cost of a crew is $2.2M ($1.1M per pilot).

PQDRs

PQDRs are a vital source of information to the Army Aviation community. The PQDRs are made out and submitted to the AMCOM to suggest corrections and improvements to aircraft and aviation associated equipment, including mission-related equipment, and to alert AMCOM to problems encountered by the user due to receipt of defective equipment. The PQDR data are used by logistic managers at AMCOM to assess the fault, failure, or condition of the item; to validate or change the current maintenance and/or inspection standards to maintain airworthiness; and improve the operational readiness of aviation equipment per AR 750–2. LTF will enhance the PQDR system by properly submitting reports as required by DA Pam 738-751, as well as monitoring responses from investigating agencies for suitability and timeliness.

For example, Figure 5.1.4 is a direct representation of the ratio of PQDRs submitted by LTF versus the rest of the Army fleet. It represents the number of PQDRs submitted per 1,000 flight hours. The data source is listed immediately after the figure.

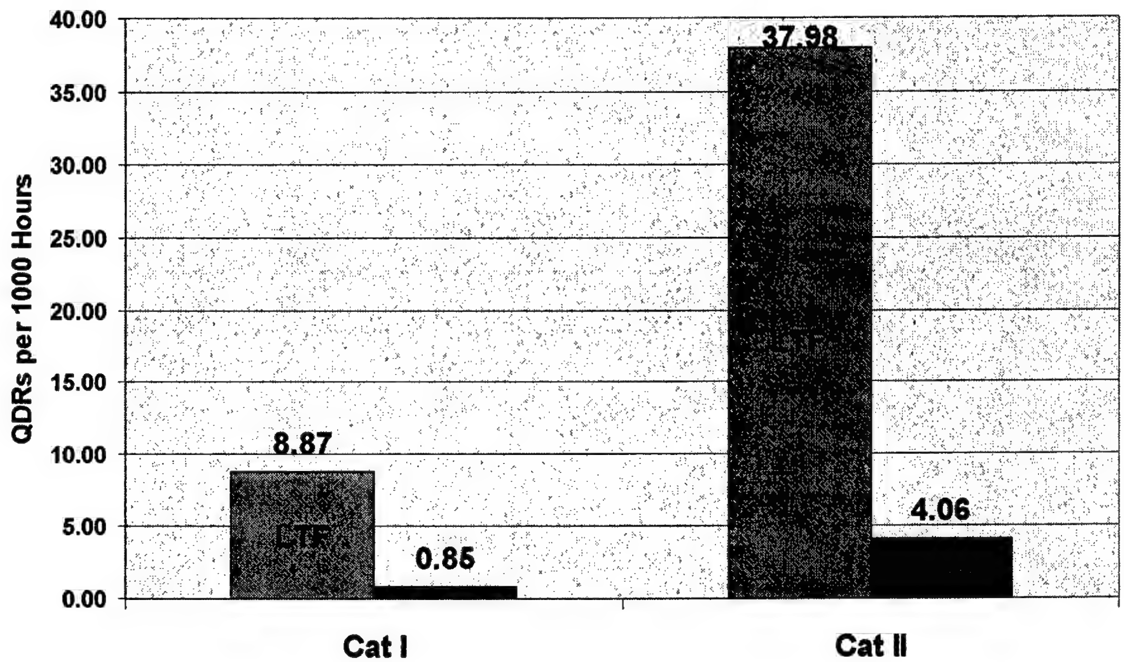


Figure 5.1.4 PQDR Metric

Data was obtained from OSMIS (avg of 2000-2002) for the Army fleets flying hours per year and ATTC records of LTF flight time per aircraft. PQDR data were obtained from the EDRS system for the relative period.

Periodicity
LTF provides metric updates to Army G4 on a monthly basis.

Value
Without adequate information, senior leaders cannot judge properly the performance of the program or its current status. To make informed decisions, they need a variety of information, including data about the Metrics, current significant events, aircraft OPTEMPO, aircraft status, and any data loss. Complete information provided by the best sources enhances the probability that the best decisions will be made. Reporting packages all relevant information and delivers it to users in a meaningful way.

There are currently five reports generated by LTF:

1. Metrics
2. Event Management
3. OPTEMPO
4. Weekly Activity Report
5. Data Loss

Metrics: The Metrics Reports are simply the Metric charts sent forward with in–depth descriptions of the depicted events (see Figures 5.1.1-5.1.4).

Event Management: The Event Management Report is depicted in chart form which graphically represents the current status of the significant events presently ongoing. The chart contains significant milestones that should be seen during the life of each event. The chart allows leaders to see, at a glance, where in the life cycle each event is and whether anything needs additional attention to be put back on course. The chart is to be automated so that when dates are placed in the appropriated blocks, the background of the block will automatically turn the correct color for the status of that event. The simple color codes will be green, amber, and red to represent whether the item is current, critical or late. Figure 5.1.5 below depicts a sample chart.

TSOF/Event	Value Category	Event Notification	Draft Prob Statement & Data I.D.	Data Collection	Data Anal & C/B Q/S	TSOF to M^2	TSOF to PM	Funding Allocated	Fielding
Special Tool	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	3/1/04 3/1/04	4/4/04 4/4/04		
PCL Bearing	6/1/02 6/1/02	6/1/02 6/1/02	6/1/02 6/1/02	6/1/02 6/1/02	6/1/02 6/1/02	6/1/02 6/1/02	3/1/04		
Rod End Replacement	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	3/1/04		
Alarm-Monitor	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	12/15/03 12/15/03	3/18/04		
CH-47 Hinge Pins									
AH-64 SDC Filters									
Engine Nozzle Mod									
Uniball Replacement									

Figure 5.1.5 Event Management Report

OPTEMPO: The OPTEMPO chart in Figure 5.1.6 depicts how the LTF aircraft are being flown in relation to the rest of the Army's fleet. The chart contains data that show the planned flight time for the aircraft, as well as plans to regain the original path should the aircraft fall behind. This report is distributed monthly to the key leaders as an informative decision making guide.

AH-64A	9/19/03	10/3/03	10/17/03	10/31/03	11/14/03	11/28/03	12/12/03	12/26/03
Average Army AH-64A	242	249	256	263	271	278	285	292
Revised Plan 480 Hours FY 03 (CEAC)	635	662	690	718	745	773	801	828
Execution Plan	645	**702**	**702**	**702**	741	780	818	857
Recovery Plan								
Actual aircraft hours								
Total Actual Hours(UniRAM)	691	703	703	703	711	711	711	715
Total Actual Hours(ELAS)	691	703	703	704	711	711	711	715
Total Acutal Hours	691	703	703	704	711	711	711	715

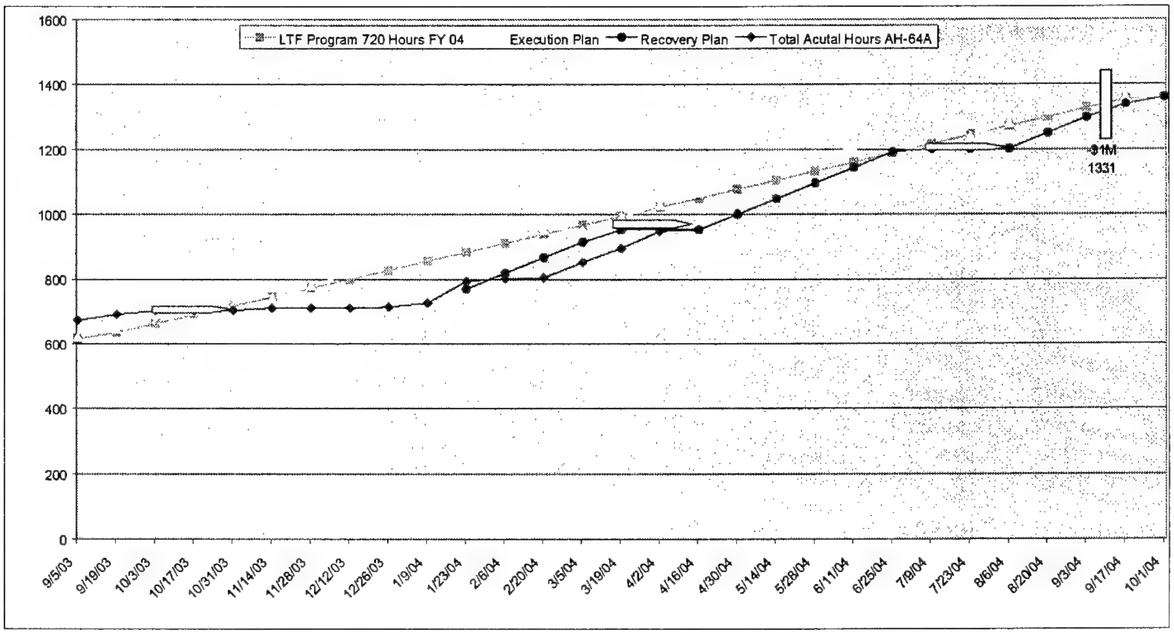


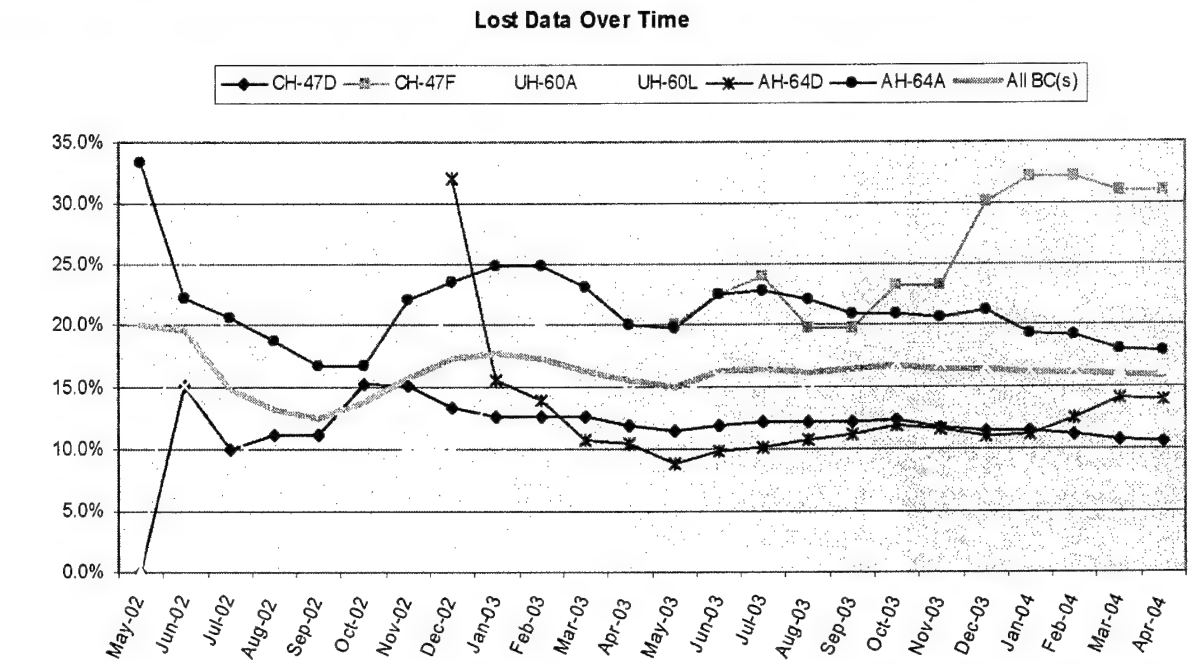
Figure 5.1.6 OPTEMPO Report

Weekly Activity Report: The WAR represents anything of significance that has occurred in the week prior. It is used as a "heads-up" report to aid management in planning for any contingencies that may occur on short notice. It is broken down by individual aircraft and will include items such as PQDRs, TIRs, significant maintenance, and other information. Figure 5.1.7 portrays a sample WAR.

	Hours Flown	Incidents	PQDRs	TIRs	Hours Until Phase	Other
AH-64A	26		2	3	267	
AH-64D	53	1		1	152	
CH-47D	32		1		98	
CH-47F	28				167	
UH-60A	49				357	
UH-60L	58			2	298	

Figure 5.1.7 Weekly Activity Report

Data Loss: LTF offers a unique capability to Army Aviation in the management of data quality. The LTF team has quality control processes for every step in data life cycle management. These processes span data generation, collection, storage, coding, transfer, and analysis. Data loss is a significant element in data quality. The LTF team strives to minimize data loss in order to provide complete, objective data for transition to CBM. Figure 5.1.8 provides an example of how data loss is tracked by the LTF team. Phase I data loss averages 16%; the objective is 5%.



	1-May	1-Jun	1-Jul	1-Aug	1-Sep	1-Oct	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul	1-Aug	1-Sep	1-Oct	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr
CH-47D	0.0%	15.2%	10.0%	11.1%	11.1%	15.3%	15.0%	13.3%	12.7%	12.7%	12.7%	11.9%	11.4%	11.8%	12.1%	12.1%	12.1%	12.4%	11.8%	11.5%	11.5%	11.2%	10.6%	10.6%
CH-47F													20.0%	22.6%	24.1%	19.7%	19.7%	23.3%	23.3%	30.1%	32.2%	32.2%	31.1%	31.1%
UH-60A	0.0%	27.6%	18.5%	18.5%	16.0%	16.7%	16.7%	21.3%	20.9%	20.0%	18.2%	17.1%	17.0%	17.6%	17.1%	16.9%	18.5%	18.3%	18.2%	18.1%	17.5%	16.9%	16.2%	16.5%
UH-60L	33.3%	15.2%	11.1%	7.7%	7.2%	8.1%	10.1%	9.9%	14.4%	13.5%	13.9%	14.6%	14.3%	15.9%	15.7%	15.3%	15.8%	16.8%	16.8%	16.5%	16.2%	16.3%	16.5%	16.4%
AH-64D								32.1%	15.5%	13.9%	10.6%	10.3%	8.8%	9.8%	10.1%	10.7%	11.1%	11.9%	11.6%	11.0%	11.1%	12.4%	14.1%	14.0%
AH-64A	33.3%	22.2%	20.7%	18.7%	16.7%	16.7%	22.1%	23.5%	24.8%	24.9%	23.1%	20.1%	19.8%	22.5%	22.8%	22.1%	21.0%	21.0%	20.7%	21.3%	19.4%	19.2%	18.0%	17.8%
All BC(s)	20.0%	19.7%	14.8%	13.2%	12.4%	13.7%	15.6%	17.3%	17.8%	17.3%	16.3%	15.5%	15.0%	16.2%	16.4%	16.1%	16.3%	16.7%	16.4%	16.4%	16.1%	16.1%	15.9%	15.9%

Figure 5.1.8. Data Loss Over Time

Total Data File Count by Aircraft Type

Type	# Good	Flights With No Data Gathered													
		A		B		C		D		E		U		Total %	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
CH-47D	363	12	3.00%	1	0.20%	17	4.20%	1	0.20%	1	0.20%	11	2.70%	43	10.60%
CH-47F	62	2	2.20%	0	0.00%	9	10.00%	0	0.00%	5	5.60%	12	13.30%	28	31.10%
UH-60Ar	10	1	7.10%	0	0.00%	3	21.40%	0	0.00%	0	0.00%	0	0.00%	4	28.60%
UH-60A	386	14	3.00%	0	0.00%	31	6.70%	3	0.60%	8	1.70%	20	4.30%	76	16.50%
UH-60L	459	12	2.20%	0	0.00%	39	7.10%	1	0.20%	10	1.80%	28	5.10%	90	16.40%
AH-64D	400	10	2.20%	2	0.40%	28	6.00%	0	0.00%	19	4.10%	6	1.30%	65	14.00%
AH-64A	456	21	3.80%	1	0.20%	24	4.30%	0	0.00%	22	4.00%	31	5.60%	99	17.80%
TOTAL	2136	72	2.80%	4	0.20%	151	5.90%	5	0.20%	65	2.60%	108	4.30%	405	15.90%

Key: A=Aborted Flight B=Bad Data Disk C=Crew D=Data Reduction E=Equipment U=Unknown

Figure 5.1.9 Data Loss Over Time

5.2. VALIDATION

Validation is the process of determining the extent that a model is an accurate representation of the real world from the perspective of the intended use of the model. Validation methods include expert consensus, comparison with historical results, comparison with test data, peer review, and independent review. LTF data validation will be documented and assessed by subject area matter and its comparison to known values.

LTF will work closely with ORCEN, USMA to ensure detailed validation process is established and conducted. In addition, LTF will collaborate with other Army agencies to ensure objective validation of LTF metrics and reports.

6.0 GOVERNANCE

Governance is the process by which strategic direction is set for this program. There are three critical layers of governance, each with a different purpose.

6.1. EXECUTIVE STEERING COMMITTEE (ESC) ROLES AND REVIEWS

The ESC meets semi-annually, more frequently if requested by the Chair. The ESC provides strategic direction, assists with funding, ensures communication within their respective organizations, and provides feedback to the Leadership Team and WG.

The preferred location for the semi-annual meeting is Huntsville, AL, to minimize total travel expenses.

A typical agenda for the ESC is TBD.

6.2. LEADERSHIP TEAM ROLES AND REVIEWS

The Leadership Team meets monthly, either face-to-face or in teleconference. This monthly meeting may also be accomplished by a Report of Actions which occurred since the last meeting. At least once per quarter, the team will meet face-to-face. The meeting is chaired by the AMRDEC PM.

The Leadership team has the responsibility to ensure that the direction set by the ESC is followed, to review progress, to ensure compliance within funding constraints, and to assist with prioritization of resources. The Team provides feedback to the WG and ensures uniform communication within their respective organizations.

6.3. WG RESPONSIBILITIES

The WG meets weekly, normally by teleconference. This team is charged with program execution. The WG is chaired by the Deputy PM appointed by the PM from AMRDEC.

The WG manages all daily operations of LTF, produces each deliverable and product on time, and prepares reports and briefings as required for the two governance bodies specified above.

The WG is also responsible for executing the communications plan described in Chapter 4. This includes daily collaboration with the community of interest as shown in Figure 6.3.1 below.

	G4	AMRDEC	AED	AMCOM	ATEC	Aviation Proponent	PEO AVN	USASC	Centers of Excellence	COBRO	Westar
Executive Steering Committee	Dir Sustainment	PM	Director of Engineering	Commander	Cdr, DTC	CDR, USAAVNC	PEO Deputy	CDR, USASC		COO	EVP
Meets Semi Annually	**Ms. Plummer**	Mike McFalls	Denny Powelson	BG(P) Pillsbury	BG McNamara	BG Sinclair	TBD	BG Smith		Jim Marsh	Randy Tieszen
Members =	10										
Leadership Team	Senior G4 Analyst	PM	T&I Mgr	Deputy to CDR	CDR, ATTC	Director, CD	Deputy PM, &/or Tech Director each MDS			COBRO PM	Westar PM
Meets Qtrly / Monthly	Ed Erb	**Mike McFalls**	Jamie Kimball	John Johns	COL Cripps	COL Golson	Rusty Weiger, CH47			Bill Braddy	Denny Crowe
							Dick Ordway, AH64				
							Keith Roberson, UH60				
Members =	11										
Working Group		DPM	T&I Mgr		ATTC				USMA		Westar PM
Meets Weekly		**Bill Braddy**	Jamie Kimball		MAJ Lee				MAJ Gorak		Denny Crow
Once a month in person					Ed Lee					Cary Pool	Lisa O'Neal
					Erich Erker						Anthony Jackson
											TimWright
											Jack Sadler
Members =	13										Clint Hanson
Community of Interest	G4 Action Officers	AMRDEC-RAM	Division Reps	IMMC Item Managers		DOTD	PM Tech Directors		COE Schools		
Meets as required											
Note: Committee Chair is bolded											

Figure 6.3.1. Governance

7.0 Funding: Omitted

8.0 Risk and exposure

8.1. Strengths, Weaknesses, Opportunities, and Threats Analysis

LTF strengths:

1. Phase I Methodology is validated.
2. Program sponsorship by Deputy Chief of Staff, G-4 (G-4).
3. Recent acknowledgement of Deputy Chief of Staff, G-3, of the need to move to CBM concept.
4. Apparently favorable orientation of the Aviation Transformation Team to CBM concept.
5. Phase I flight test accomplishments to date; flying hours accrued, off-site excursions accomplished, excellent safety record.
6. PMs for Apache, Black Hawk, and Chinook have expressed enthusiasm for the LTF program.
7. Key members of the AED have expressed enthusiasm for the LTF program.
8. LTF Program has a favorable professional reputation. The ATTC is recognized throughout the Army for its testing expertise. The LTF Team is strong and composed of strong team members.
9. ATTC is conducting the program, using proven test methodology. This ensures both regimen and rigor in the execution and data collection effort.
10. Usage methodology is leading-edge technology.
11. The program has the flexibility to do value added testing.

LTF Weaknesses:

1. The Program has been very slow getting Technical Summaries of Findings (TSOF) into the hands of decision-makers. There is no clear recipient of the TSOF.
2. The program is understaffed. There is only a small corps of "doers."
3. The team got a late start in developing the Business Plan. The plan is still in "development."
4. The Business Plan has not been "sold" to the G-4 (yet).
5. Phase I is not structured to allow easy transition to Phase II. This includes execution, data collection (methods and tools), data analysis, and programmatic issues.
6. The Program is not staffed or prepared for Phase II or Phase III. We cannot adequately plan or equip for follow-on phase without funding. This will cause a delay in the start date of Phase II after approval. The current Phase II plan is very rough, having been developed to provide a rough-order-of magnitude estimate to support an un-financed requirement deliberation.
7. The Program has not established procedures for non-intrusive collection of LTF Phase II data from units (see above).
8. The Program seems to be oriented on fatigue life-limited parts to the exclusion of time-between-overhaul parts and condition change parts, or any other aspect of maintenance, to include supply actions, maintenance procedures, inadequate or incorrect documentation, and maintenance requirements.
9. There is a lack of clarity concerning criteria for TSOF initiation.

10. Phase II scope of effort is not clearly defined, yet the Program is seeking to initiate the follow-on Phase II (see above). In addition, we need to know where we want to be before we go too far.
11. The Scope of the Program seems ambitious when compared to the funding profile. There is no funding for Phase II.
12. The Program needs to develop O&S cost bogey for CBM and the cost of transitioning to CBM versus the time-based maintenance scheme in current use.
13. The Program needs senior-level buy-in for the path to CBM.
14. The Program has not capitalized on the expertise of the UK CH-47 operators relative to their experience with health monitoring and CBM. Perhaps we need to conduct an information gathering effort to see what others are doing.
15. The LTF Phase I efforts may actually be losing up to 15% of the test data.
16. LTF cost-benefit analyses need endorsement by G-4 and AAA.
17. There is no clear and accepted definition of CBM.
18. Phase II sample stratification is not defined.
19. The LTF Team has low confidence in current analytical methodology.
20. We are dependent on the OSMIS database, but the data available on OSMIS is usually a year old.

LTF Opportunities:

1. LTF as leader of Army-wide transition to CBM.
2. ATTC is poised to start training for Unmanned Aerial Vehicle (UAV) utilization upon notice of budget approval.
3. Potential advocacy of Commanding General, U.S. Army Safety Center, to Chief of Staff U. S. Army on behalf of the LTF Program:

a. Advocacy of other senior leaders: LTG Curran, MG Armbruster, MG Bergantz, MG Miles, MG Pillsbury, Mr. Bogosian, BG McNamara, and BG Sinclair.

b. Appropriate involvement of AED.

4. Approval of Phase II.
5. Potential to use Maintenance Data Recorders for LTF. This would increase the Phase II LTF sample size to the entire AH-64D fleet at a small incremental cost.
6. Potential to leverage the use of university Centers of Excellence.
7. Potential to tie in CCAD analysis to validate LTF equipment.
8. Potential to develop a process to minimize data loss (Data Recovery Plan).
9. Expansion of LTF to "jointness," interagency, and international venues.
10. Expansion of LTF to ground vehicles and weapons systems.
11. Announced plans to add aircraft types to the Army fleet may require LTF to incorporate new aircraft to Phase I. Scope and duration of Phase I may evolve with changing requirements.
12. Approval of Phase III

LTF Threats:

1. A new administration with as yet undetermined political views may mean fewer available funds for the military.
2. Certain personnel in AMCOM desire to run the LTF Program.

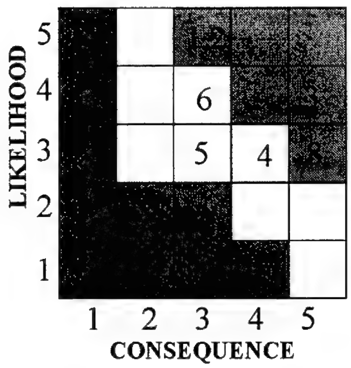
3. Technology required for seamless integration of Phase III may not be available in a timely fashion. The availability of technology may in part determine the length of Phases I and II
4. An unfavorable DSC Decision relative to LTF methodology.
5. Fragmented effort may dilute the ability of LTF to proceed.
   a. South Carolina National Guard – VMEP and Common Transition System – Army (CTS-A).
   b. CLOE.
   c. Logistics Modernization Plan.
   d. DSC IPT
   e. Aviation Logistics Modernization Plan.
   f. Demands of AED may dilute the efforts of the LTF Program and cause a loss of focus.
   g. 2LM.

8.2. RISKS TO LTF PROGRAM EXECUTION

1. Limited analysis scope in Phase I – High Risk.
2. Slow progress on establishing the Process for Technical Summaries of Findings – High Risk.
3. Readiness to transition to Phase II – High Risk.
4. LTF roadmap to CBM not approved – Medium Risk.
5. LTF diverted by extraneous demands for data and analyses – Medium Risk.
6. Required technology availability for Phase III – Medium Risk.
7. Other commands or organizations may attempt to gain control of the LTF Program – Low Risk.
8. Phase II funding not approved – High Risk.
9. Funding for UAV not approved – High Risk.

Lead-the-Fleet Program

Lead-the-Fleet Risk Assessment



#	Risk	Type Risk
1	Limited analysis scope in Phase I	T,S
2	Slow progress on establishing the Process for Technical Summaries of Findings	T
3	Readiness to Transition to Phase II	T,S
4	LTF roadmap to Condition Based Maintenance not approved.	T,S
5	LTF diverted by extraneous demands for data and analyses	S
6	Required Technology Availability for Phase III	T
7	Other commands or organizations may attempt to gain control of the LTF Program.	S
8	Phase II Funding not Approved	C

T = Technical Risk
C = Cost Risk
S = Schedule Risk

Internal working paper for the team responsible for Lead the Fleet. Not for distribution outside of the group members or the direct addressees.

Figure 8.2.1. Lead the Fleet Risk Assessment Summary

Internal working paper for the team responsible for Lead the Fleet. Not for distribution outside of the group members or the direct addressees

Lead-the-Fleet Program Page 1 of 8

Risk Title Limited Analysis Scope in Phase I **Date** 14 April 2004
Program(s) ______ **Risk Owner / Other Key Players** Braddy/ Crowe/ et. al.

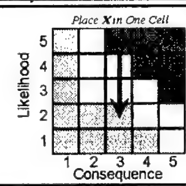
Description of Risk:
The limited analysis scope in Phase I may delay the approval to begin Phase II.

Statement of Basic Cause:
The Program is oriented on Fatigue Life Limited parts to the exclusion of Time Between Overhaul parts and condition change parts.

Consequence If Risk is Realized:
Delay of the approval to begin Phase II.

Risk Type *(Check one)*
- [x] Schedule
- [ ] Cost
- [x] Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date Scheduled	Date Actual	Success Criteria	Risk Level if Successful	Comments
Incorporate Time Between Overhaul parts and condition change parts to the routine Analytical process	6/04		Submit one TSOF each concerning a TBO item and a condition change item.	3,2	Beginning the TBO and condition change items will Reduce this risk from high to low.

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Figure 8.2.2. LTF Limited Analysis Scope Risk Reduction Plan

Lead-the-Fleet Program Page 2 of 8

Risk Title Slow progress on establishing the Process for Technical Summaries of Findings **Date** 14 April 2004

Program(s) ______ **Risk Owner / Other Key Players** Braddy/ Crowe/ et. al.

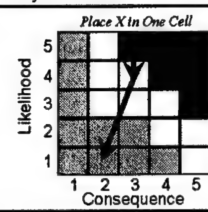
Description of Risk:
The Program has been slow to define and establish the TSOF Process.

Statement of Basic Cause:
There has been uncertainty concerning the criteria for TSOF initiation, format, content, staffing procedures, and target audience.

Consequence if Risk is Realized:
Delay of the approval to begin Phase II.

Risk Type
(Check one)
[X] Schedule
[ ] Cost
[X] Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date: Scheduled	Date: Actual	Success Criteria	Risk Level if Successful	Comments
Submit existing draft TSOFs	4/04		PM releases TSOFs	3,4	5 TSOFs ready for Approval
Establish TSOF initiation criteria	5/04		T&A IPT Begins to use newly established criteria	3,4	
T&A IPT Understands and uses criteria	5/04		Process flows smoothly	2,1	

Figure 8.2.3. Technical Summary of Findings Risk Reduction Plan

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Lead-the-Fleet Program

Page 3 of 8

Risk Title Readiness to Transition to Phase II **Date** 14 April 2004

Program(s) ______ **Risk Owner / Other Key Players** Braddy/ Crowe/ et. al.

Description of Risk:

The Program may not be ready to transistion to Phase II upon the approval to begin Phase II.

Statement of Basic Cause:

Phase II Scope is not defined, Procedures, staffing and staff training are not in place

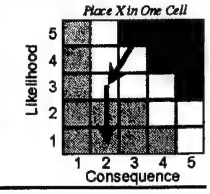
Consequence if Risk is Realized:

Delay of effective Program Initialtion upon the approval to begin Phase II.

Risk Type *(Check one)*

- [X] Schedule
- [ ] Cost
- [X] Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date: Scheduled	Date: Actual	Success Criteria	Risk Level if Successful	Comments
Define the Scope of Phase II	5/04		Agreed-upon Scope of Work	2,3	
Organize to meet the planned scope	10/04		Agreed-upon Organization	2,3	
Create un-obtrusive data collection method	10/04		Methods tested at a target unit	2,3	
Create an Executive Data Base management System	1/05		Test of loading and down loading LTF data	2,1	

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Figure 8.2.4. Transition to Phase II Risk Reduction Plan

Internal working paper for the team responsible for Lead the Fleet. Not for distribution outside of the group members or the direct addressees.

Lead-the-Fleet Program

Page 4 of 8

Risk Title LTF roadmap to Condition Based Maintenance Not Approved **Date** 14 April 2004

Program(s) ____________ **Risk Owner / Other Key Players** Braddy/ Gorak/ et. al.

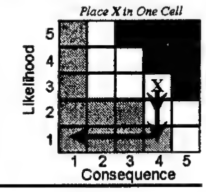
Description of Risk:
The LTF model roadmap to Condition Based Maintenance is only notional until it is approved.

Statement of Basic Cause:
One of the tenets of Phase III is that the Army's maintenance concept will be Condition Based Maintenance. No model has been approved or published

Consequence if Risk is Realized:
Delay of the approval to begin Phase III.

Risk Type (Check one)
☒ Schedule
☐ Cost
☒ Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date Scheduled	Date Actual	Success Criteria	Risk Level if Successful	Comments
Invite G-4 Staff elements to view and Collaborate with LTF Program on the Definition of Condition Based Maintenance	6/04		Initial Meeting w/ G-4 on CBM definition	4,2	
Establishment of the definition of CBM	9/05		Concurrence of DA G-staff	4,1	
Decision Brief to CSA	10/05		CSA Approves CBM Concept	1,1	Reduce this risk from med to low.

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Figure 8.2.5. LTF Roadmap to Condition-Based Maintenance Risk Reduction Plan

Internal working paper for the team responsible for Lead the Fleet. Not for distribution outside of the group members or the direct addressees.

Lead-the-Fleet Program

Page 5 of 8

Risk Title LTF diverted by extraneous demands for data and analyses **Date** 14 April 2004

Program(s) ____________ **Risk Owner / Other Key Players** Braddy/ Crowe/ et. al.

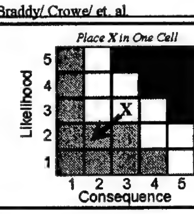
Description of Risk:
The limited resources of LTF program leave very little available to the pursuit of tasks not directly related to LTF data collection, analysis, and reporting.

Statement of Basic Cause:
As the program grows, and becomes more widely recogized, requests from other agencies may overextend the LTF Program.

Consequence if Risk is Realized:
Delay of crucial program milestones.

Risk Type (Check one)
☒ Schedule
☒ Cost
☐ Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date Scheduled	Date Actual	Success Criteria	Risk Level if Successful	Comments
LTF staff recommends protocols for acceptance of "outside" work	6/04		LTF Staff agrees on protocols	3,3	
PM Establishes protocols for the acceptance and pursuit of "outside" work.	7/04		Protocols made available To other organizations and units.	2,2	Reduce this risk from med to low.

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Figure 8.2.6. Diversion of LTF Effort Risk Reduction Plan

Lead-the-Fleet Program

Page 6 of 8

Risk Title Required Technology Availabity for Phase III **Date** 14 April 2004

Program(s) ______ **Risk Owner / Other Key Players** Braddy/ Crowe/ et. al.

Description of Risk:

Technology required for the seamless intergration of CBM to the field may delay the commencement of Phase III.

Statement of Basic Cause:

CBM has not been defined, A data collection methodology has not been defined, An executive data base management system must be designed and deployed.

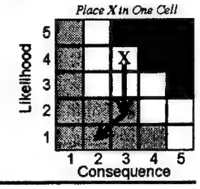
Consequence if Risk is Realized:

Delay of the approval to begin Phase III.

Risk Type *(Check one)*

- [X] Schedule
- [ ] Cost
- [ ] Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date: Scheduled	Date: Actual	Success Criteria	Risk Level if Successful	Comments
Definiton of CBM esatblished	10/05		CSA approves CBM	3,2	
Data collection methodology and process Equipment identified.	1/06		DA G-staff briefed on data collection concept	3,2	
Process and equip't fielded to first test unit	9/06		Test unit established and operational.	2,1	Reduce this risk from med to low.

Figure 8.2.7. Availability of Technology for Phase III Risk Reduction Plan

Lead-the-Fleet Program

Page 7 of 8

Risk Title Phase II funding not approved **Date** 14 April 2004

Program(s) ______ **Risk Owner / Other Key Players** Braddy/ Crowe/ et. al.

Description of Risk:

Phase II funding is in jeopardy for FY06.

Statement of Basic Cause:

Funding for Phase II in FY06 is currently a UFR.

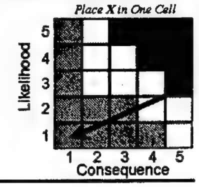
Consequence if Risk is Realized:

Delay of the approval to begin Phase II.

Risk Type *(Check one)*

- [ ] Schedule
- [X] Cost
- [ ] Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date: Scheduled	Date: Actual	Success Criteria	Risk Level if Successful	Comments
Develop Business Plan to support LTF	4/04		Draft approved by PM	5,3	
Brief Ms. Plummer on Draft Business Plan	4/04		Draft BP favorably viewed	5,3	
Business plan completed	5/04		BP approved by PM	5,3	
Re-brief G-4 Sustainment on UFR	5/04		G-4 Sustainment recommends Phase II funding	1,1	Reduce this risk from high to low.

Figure 8.2.8. Phase II Funding Risk Reduction Plan

Internal working paper for the team responsible for Lead the Fleet. Not for distribution outside of the group members or the direct addressees.

Lead-the-Fleet Program

Page 8 of 8

Risk Title UAV funding not approved for LTF **Date** 14 April 2004

Program(s) ________ **Risk Owner / Other Key Players** Braddy/ Crowe/ et. al

Description of Risk:
Phase II funding is in jeopardy for FY06.

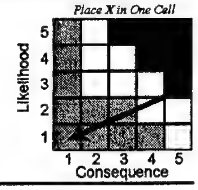
Statement of Basic Cause:
Funding for Phase II in FY06 is currently a UFR.

Consequence if Risk is Realized:
Delay of the approval to begin LTF UAV Testing.

Risk Type
(Check one)

- ☐ Schedule
- ☒ Cost
- ☐ Technical / Quality

Place X in One Cell



Risk Reduction Plan

Action/Event	Date: Scheduled	Date: Actual	Success Criteria	Risk Level if Successful	Comments
Leverage the proponecy of the USAAVNS Commander	5/04		CG, USAAVNS exerts influence to obtain funding	5,3	
Clarify the meaning of contractor logistic Support	5/04		Show that CLS is not the Answer to UAV sustainment	5,3	
Re-brief G-4 Sustainment on UFR	5/04		G-4 Sustainment recommends Phase II funding	1,1	Reduce this risk from high to low.

Internal working paper for the team responsible for Lead the Fleet. Not for distribution outside of the group members or the direct addressees.

Figure 8.2.9. UAV Funding Risk Reduction Plan

9.0 OTHER POTENTIAL SYNERGIES

9.1. DYNAMIC INVESTIGATION CAPABILITY

TBP

9.2. PARALLEL OR VALUE ADDED TESTING

The LTF project provides an opportunity for conducting Value Added (VA) testing. VA tests are conducted using one or more of the LTF aircraft, when the customer (normally the aircraft PM) has a scope and objective separate from LTF testing. The LTF aircraft are available for both ground and flight test on a non-interference or minimum impact basis.

To qualify as VA, the test should provide add value to the Army or other Service. When carefully controlled, a VA test provides a synergistic effect by providing an opportunity to test aircraft components in a controlled environment without the increased burden of paying for aircraft flight hours.

VA tests may include new or redesigned aircraft components or subcomponents, weapons systems, ammunition, or avionics. VA tests may also include new vendor qualification, the evaluation of expanded aircraft maneuver requirements, aircraft vulnerability testing, or other urgent Warfighter requirements.

The following are basic ground rules for a VA test:

- During a VA test, the LTF aircraft will not deviate from the approved LTF profiles.

- The LTF aircraft will remain fleet representative and in an approved LTF configuration. PM LTF will approve, on a case-by-case basis, minor modifications, such as instrumentation. Modifications will not cause excessive down-time, and the down-time will not adversely affect the LTF aggressive OPTEMPO.

- All costs for the LTF VA, except for flight hours, will be at the expense of the VA customer. This includes any damage caused to the aircraft as a result of conducting the VA test.

- The ATTC will continue to collect all required LTF data while conducting the VA test. Required data include pilot data cards; reliability, availability, and maintainability data; and electronic data.

The following is the sequence of events for accepting an LTF VA test:

- The potential VA customer contacts the ATTC LTF test team.

- The ATTC LTF test team will conduct a technical review of the intended test. This team will develop an initial recommendation as to feasibility, timing, and impact. ATTC will then present recommendations to the LTF PM.

- The LTF PM will make the final determination as to compatibility of all VA tests.

- The ATTC LTF test team will continue to monitor the VA test to ensure compliance with the requirements outlined above.

Essential Elements of Information for Test Execution:

- Schedule
- VA test scope and objectives
- Off-site requirements
- Aircraft modification requirements
- Impact to the LTF OPTEMPO

LTF Responsibility:

- The VA test customer will fund "all" costs associated with the test, except LTF aircraft flight hours. Cost will include, but not be limited to, Per Diem, off-site aircraft maintenance labor, aircraft recovery cost when off-site, and parts shipment when off-site. This includes any damage caused to the aircraft as a result of conducting the VA test.

- ATTC will assume all duties and responsibilities normally associated with the VA test (i.e., coordination for the aircraft at the required times, pilot requirements, aircraft modification, Airworthiness Release (AWR) and Local Flight Release, Safety Release, Human Use Committee, etc.).

After the VA test, ATTC will provide a report of flight time flown to the LTF PM. ATTC will also ensure the aircraft is de-configured as required (at the expense of the VA test customer) or coordinate to have the aircraft remain in the modified condition.

9.3. Two Level Maintenance

LTF is the only current program that will deliver information to support development of CBM and 2LM. The Army's Logistic Transformation envisions maintenance operations will be conducted within a two-tier maintenance system characterized by "replace forward ad repair rear." This two-tiered system will be comprised of field and sustainment maintenance levels and massed effects rather than capabilities. Field maintenance will focus on getting weapon systems back into the fight as quickly as possible. Every platform will have a crew chief capable of fixing the majority of "plug and play" problems identified by onboard prognosis and diagnostic systems and maintain the aircraft at an overall high state of readiness. Rapid response combat repair teams will support more complex repairs that fix or evacuate the aircraft, as necessary and permissible by the tactical situation.. The focus of sustainment maintenance will be the supply system through contractors and depots. There,

major assemblies and components will be repaired and returned to the supply system for re-issue. CBM will be an enabler for effective 2LM.

9.4. FORECASTING

LTF will provide the framework for logisticians to anticipate sustainment requirements. In 2010, Army forces will rapidly deploy with sufficient capability to quickly contain, stabilize, or terminate a crisis. This requires the integration of logistics functions into a totally integrated deployment, distribution, and sustainment system supported by an information structure that provides an unprecedented level of forecasting requirements. LTF initiatives will enable logisticians to anticipate sustainment requirements by theater based on usage. There will be continuous improvement of anticipated sustainment requirements at both the tactical and National Maintenance Level.

9.5. OTHER GROUND AND AIR SYSTEMS

The LTF systems approach is applicable to all major weapons systems. The LTF program is a systems approach that can be tailored to solve critical problems associated with any major weapons system that involves component reliability, safety, O&S costs drivers, and readiness. The LTF program will directly address the Army G-4 CLOE initiative for synchronization of sustainment and technology. The purpose of CLOE is to ensure sustainment interoperability among self-reporting self-diagnosing platforms and the Future Force sustainment system network to provide the highest state of operational capability, mission capability, and combat power, while reducing the logistics footprint. Within the scope of CLOE, LTF will provide a systems approach towards synchronization of evolving doctrine, technology, and business processes; integration of technology; commonality; interoperability within a networked sustainment environment; and life cycle management.

9.6. ROTORCRAFT COE

In 1982, the first three RCOEs were established at the Georgia Institute of Technology, the University of Maryland, and the Rensselaer Polytechnic Institute of Troy, NY. In 1996, the Army and NASA formed the National Rotorcraft Technology Center (NRTC). A key function of the NRTC is to coordinate rotorcraft research activities of the universities, industry, and government. NRTC selected the Georgia Institute of Technology, the University of Maryland, and the Pennsylvania State University as the three RCOEs. On 6 September 2000, the joint NRTC renewed the standing of the three RCOEs by selecting them for five-year grants. Awards were made to the Georgia Institute of Technology, the University of Maryland, and the Pennsylvania State University. The three grants total $2.3M per year. These grants will cover efforts from January 2001 to December 2005.

The RCOEs were established to support long-term basic research objectives and to establish a significant dual-use technology base. The purpose of the RCOE program is to provide a critical mass of multi-disciplinary research capability at several universities to provide interdisciplinary programs aimed at elimination of rotorcraft technology barriers. A range of faculty capabilities and appropriate rotorcraft-related course work in a number of disciplines were required to establish the centers. The involvement of historically black colleges and

universities or other minority institutions in the execution of the research activities was also necessary

The research topics requested under the RCOE grants are (1) efficient low-noise rotors, (2) affordability, (3) low-vibration dynamic systems, (4) advanced drivetrains (excluding engines), (5) smart and composite structures, (6) integrated automated cockpits, (7) advanced dependable day/night adverse weather capability, (8) highly reliable safe operations, (9) digital-optical integrated flight controls, and (10) Vertical Take Off and Landing (VTOL) air traffic control systems. Research topics are focused on basic scientific issues that are of unique importance to rotorcraft and that have the potential for making significant contributions to government and industry research goals and missions.

The NRTC, located at the NASA Ames Research Center, also manages a unique research program performed by the Rotorcraft Industry Technology Association (RITA). The RITA conducts cost-sharing (50/50 government/industry) research by the rotorcraft industry and universities. RITA was set up to address more of the near-term and mid-term versus the long-term technologies.

The Army LTF program will incorporate the technology development and cadre of scientists, engineers, and students at RCOEs to assist LTF in spearheading the Army Aviation to CBM. In addition, LTF will incorporate other universities and colleges that lead the field in applicable CBM technology. Finally, LTF will establish partnership with necessary Army agencies, such as AED and PEO Aviation, to synergize the Army efforts to incorporate industry and academia in CBM research and development.

9.7. POTENTIAL OF UAV TIED TO AVIATION PROPONENCY

TBP

Appendix A – Acronym List

Acronym	Definition
2LM	Two Level Maintenance
AAA	Army Audit Agency
AED	Aviation Engineering Directorate
AMC	Army Material Command
AMCOM	Aviation and Missile Command
AMRDEC	Aviation and Missile Research, Development, and Engineering Center
ATEC	U.S. Army Test and Evaluation Command
ATTC	Aviation Technical Test Center
BLOB	Binary Large Object
CA	Cost Avoidance
CBA	Cost Benefit Analysis
CBM	Condition-Based Maintenance
CCAD	Corpus Christi Army Depot
CECOM	Communications and Electronics Command
CLOE	Common Logistics Operating Environment
C-MIGITS	Coupled Miniature Integrated Global Positioning System/Inertial Navigation System Tactical System
CONUS	Continental United States
COR	Contracting Officer's Representative
CTS-A	Common Transition System-Army
DA	Department of the Army
DA Pam	Department of the Army Pamphlet
DataMARS	Data Monitor, Analysis, and Reporting System
DCD	Directorate of Combat Developments
DCSLOG	Deputy Chief of Staff for Logistics
DLA	Defense Logistics Agency
DoD	Department of Defense
DSC	Digital Source Collection/Collectors
DTC	Developmental Test Command
EDRS	Electronic Deficiency Reporting System
ELAS	Enhanced Logbook Automation System
EMA	Essential Maintenance Actions
FDSC	Failure Definition Scoring Criteria
FGC	Functional Group Code
FHC	Field/High/Centerline
FMC	Fully Mission Capable
FMECA	Failure Mode, Effects, and Criticality Analysis
FRB	Failure Review Board
FSR	Fatigue Substantiation Report
GAG	Ground-Air-Ground
GPS	Global Positioning System
HQDA	Headquarters, Department of the Army

Appendix B (Pgs B1-B65) = Report Pgs 37-101

Acronym	Definition
HUMS	Health Usage Monitoring System
IETM	Integrated Electronic Technical Manual
IMMC	Integrated Materiel Management Center
INS	Inertial Navigation System
IPT	Integrated Product Team
LIDB	Logistics Information Database
LOGSA	Logistics Support Activity
LTF	Lead The Fleet
MAF	Mission Affecting Failures
MDS	Model, Designation, and Series
MFT	Maintenance Flight Time
MMH	Maintenance Man-Hours
MTF	Maintenance Test Flight
MWO	Modification Work Order
NAVAIR	Naval Air Systems Command
NRTC	National Rotorcraft Technology Center
O&S	Operations and Support
ODCS	Office of the Deputy Chief of Staff
OEM	Original Equipment Manufacturer
OPTEMPO	Operational Tempo
ORCEN	Operations Research Center
OSMIS	Operating & Support Management Information System
PEO	Program Executive Office
PLL	Prescribed Load List
PM	Preventive Maintenance
PM	Program Manager
PQDR	Product Quality Deficiency Report
QDR	Quality Deficiency Report
RAM	Readiness, Availability, and Maintainability
RAMS	Reliability, Availability, and Maintainability Safety
RCM	Reliability-Centered Maintenance
RCOE	Rotorcraft Center of Excellence
RITA	Rotorcraft Industry Technology Association
RSOU	Relative Severity Of Usage
SDC	Sample Data Collection
SFDLR	Stock Funded Depot Level Reparable
TBO	Time Between Overhaul
TBP	To Be Published
TCOR	Technical Contracting Officer's Representative
TDS	Tangible Dollar Savings
TIR	Test Incident Report
TM	Technical Manual
TRADOC	Training and Doctrine Command
TSOF	Technical Summary of Findings
UK	United Kingdom

Appendix B (Pgs B1-B65) = Report Pgs 37-101

Acronym	Definition
ULLS-A	Unit Level Logistics System-Aviation
UniRAM	Unified Readiness, Availability, and Maintainability
USASC	U.S. Army Safety Center
USMA	U.S. Military Academy
V&V	Verification and Validation
VDLS	Visual Data Library System
VMEP	Vibration Monitoring Enhancement Program
VTOL	Vertical Take Off and Landing
WAR	Weekly Activity Report
WG	Working Group
WUC	Work Unit Codes

Appendix B (Pgs B1-B65) = Report Pgs 37-101

Appendix B – References

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Appendix B (Pgs B1-B65) = Report Pgs 37-101

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Report Documentation Page – SF 298

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14. ABSTRACT Army helicopter system and component scheduled maintenance, overhaul, and retirement actions typically are based on calendar times and flight hours. These times are based on a composite worst-case (CWC) presumption of helicopter regime usage. CWC usage is derived for each U.S. Army helicopter model to capture the most severe usage that helicopter models can ever be expected to experience. Knowledge of actual operational usage can be used to identify unsafe usage, refine scheduled maintenance actions, and predict unscheduled maintenance requirements. The purpose of the Lead the Fleet (LTF) program is to gain better insight into the accumulated damage that each U.S. Army helicopter could experience during actual operational usage and to use that knowledge to evaluate overhaul and retirement times, increase safety and operational readiness, reduce costs, and recommend condition based maintenance actions. This technical report reflects West Points' Operational Research Center of Excellence (ORCEN) analysis and restructuring of the LTF program.						
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